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LIGATION AND DIVISION OF THE ABDOMINAL AORTA FOR METALLIC EMBOLUS FROM THE HEART

POSTOPERATIVE OBSERVATIONS OF THE CIRCULATION IN THE EXTREMITIES

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SINCE THE ORIGINAL REPORT by Sir Astley Cooper, in 1817, of ligation of the abdominal aorta for aneurysm, the method and results have interested many surgeons. The first successful case of ligation of the terminal aorta was reported by Brooks,¹⁰ in 1926. The subject was reviewed by Bigger,¹ Elkin,² and Matas,³ in 1940, with discussion of the problems involved and of the complications which frequently follow. Gangrene, erosion of the vessel, hemorrhage, and recurrence of the aneurysm are common.

These authors collected a series of 30 cases of ligation of the abdominal aorta for aneurysm of the aorta or of the common iliac vessels. Elkin² included four instances of ligation of the aorta for trauma or tumors. Morton and Scott⁴ reported an additional case of ligation for aneurysm of the bifurcation of the aorta in 1944, with the patient living for seven months. Another case was reported by Monohan⁵ with survival for three months. Both of these cases died of hemorrhage resulting from erosion into the small intestine. Ormond, Harkins, and Smith⁶ reported a case of ligation of the aorta for a ruptured aneurysm, with the patient surviving for one day. Nario⁷ reported a case of partial ligation of the aorta for aneurysm of the aorta and common iliacs, with survival. Delannoy⁸ excised the bifurcation of the aorta for thrombosis with recovery in 1945. Friehe and Morel⁹ successfully excised the bifurcation of the aorta for thrombosis, with postoperative improvement in the circulation of the extremities, a bilateral lumbar sympathectomy was performed.

Of the 36 cases appearing in the literature only 12 have been to any degree successful.

The following case is reported since it is the only one in which excision of the bifurcation of the aorta was necessitated by erosion of a portion of the

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wall of the aorta by a foreign body within its lumen The patient made an uneventful clinical recovery

CASE REPORT

This 22-year-old male soldier was treated at overseas hospitals for a stricture of the urethra, physical examinations were normal except for this condition. He sustained a penetrating wound of the left arm and chest, May 26, 1945, when he was shot with a .45-caliber pistol, and was admitted to an hospital shortly after the injury. At this time he was breathing quietly and was not in shock. A wound of



FIG 1—Retouched roentgenogram of chest shortly after injury showing an hydro-pneumothorax, displacement of the mediastinum to the right and the foreign body within the heart

entrance was present on the lateral aspect of the left arm with a wound of exit from the arm on the medial aspect near the axilla, the bullet then entered the chest between the 4th and 5th ribs. Roentgenograms showed the fracture of the humerus was treated by debridement and a "hanging cast" (Fig 1). After plasma had been administered the fracture of the humerus was treated by debridement and a "hanging cast", the wound of the chest was debrided and sutured, with drainage. Fourteen hours later his blood pressure in both arms was 115/70, pulse 100, and there was no dyspnea or cyanosis.

On the following day his condition continued unchanged except that a loud "swishing" murmur was heard over the sternum, the murmur had not been present the preceding day. At this time it was noted that the pulses in the feet were equal. Thoracentesis

was performed on four occasions, and by June 13, 1945, the mediastinum had returned to its normal position (Fig 2), the murmur over the precordium diminished

On June 21, 1945, he suddenly complained of pain, coldness, and numbness of the right foot. On examination, there was no palpable dorsalis pedis pulsation on the right although the one on the left was good. The following day the femoral pulse on the right also disappeared, the pulsations of the arteries of the left lower extremity diminished. On June 24, 1945, a roentgenogram was taken which showed the 45-caliber bullet at the bifurcation of the aorta. At this time the left dorsalis pedis pulse had disappeared, with the femoral pulsation definitely diminished.



FIG 2—Retouched roentgenogram following disappearance of the hydropneumothorax, with the foreign body in the heart

During the following two weeks the murmur over the precordium diminished in intensity, and the palpable pulsations in the lower extremities varied, although faintly palpable on either side. The condition of the feet continued "good, without edema."

On July 12, 1945, a left paravertebral lumbar sympathetic block was performed.

An attack of severe, sharp, stabbing precordial pain radiating to the abdomen and right hip region occurred on July 22, 1945. A very loud systolic murmur was heard over the entire chest, the abdomen was rigid, with tenderness most marked in the right lower quadrant. Pulsations were felt in both dorsalis pedis arteries. It was believed that in view of the changes in pulsations in the extremities that the pain had been produced by shifting of the bullet in the aorta or by a dissecting aneurysm of the aorta. It was also feared that blood had leaked into the peritoneal cavity, but the pain and tenderness disappeared within two days. During the following nine days the pulse in the right lower

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extremity varied in amplitude, with those on the left absent. On August 1, 1945, the episode of chest and abdominal pain recurred, with all symptoms and signs subsiding on the following day. On August 9, 1945, he was transferred to the United States, and admitted to Ashford General Hospital, November 13, 1945, complaining of weakness and fatigability of both legs and of coldness of the right foot.

Physical examination on admission revealed all wounds to be completely healed. A loud systolic murmur was present over the precordium, maximum at the level of the right third intercostal space. A loud diastolic murmur was also present, but with a short interval between, giving the total murmur an almost continuous quality. A thrill was

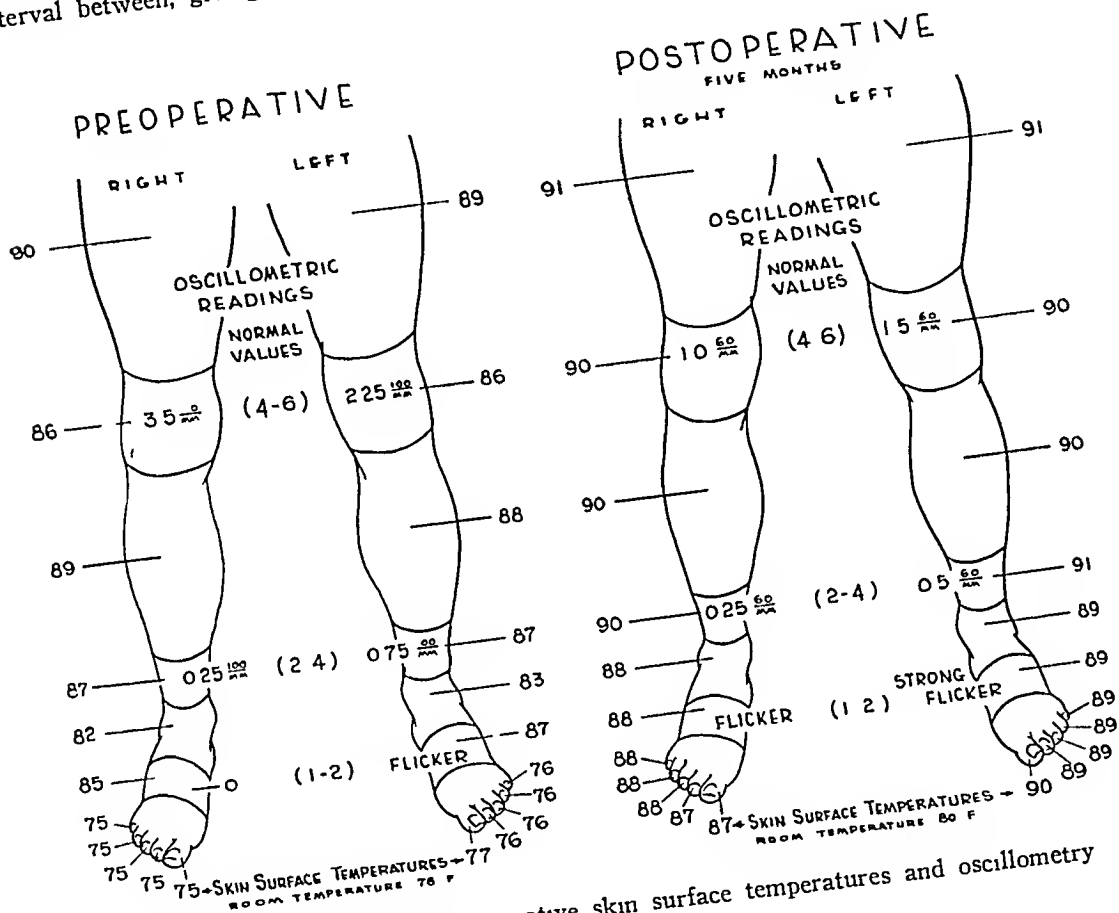


FIG 3—Preoperative and postoperative skin surface temperatures and oscillometry

palpable in the same region. The bruit was transmitted to the left upper chest, lower neck, and intrascapular region. It could also be heard along the aorta to the level of the umbilicus. Blood pressure in the upper extremities was 130/60 right, 130/90 left.

Vascular Evaluation The right foot became pallid on elevation. There were no trophic changes in the extremities, no sweating, scleroderma or edema. The left dorsalis pedis pulse was faint, the right absent. Both posterior tibial pulses were absent. The popliteal pulsations were moderate. The upper extremities were normal. Oscillometry and skin surface temperatures were as shown in Figure 3.

Roentgenographic and fluoroscopic examination of the chest showed no evidence of pathology in the thoracic aorta. Moderate enlargement of the right auricle was present. C T ration was 152/296. Examination by means of Bucky and planeographic films failed to demonstrate any abnormality of the thoracic aorta. Examination of the lumbar

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region revealed a large metallic foreign body lying at the third lumbar interspace slightly to the left of the midline (Fig 4) The mass pulsed with a downward motion in time with the pulsations of the aorta

Electrocardiogram revealed a normal sinus rhythm, PR interval of 20 Sec, QRS complexes 07 Sec, T₂ notched and T₃ diphasic

White blood count was 6,750 with hemoglobin of 15 Gm , urmalysis was normal Frei test was positive, Kahn negative

The soldier's hospital course was uneventful until December 8, 1945, when, while sitting in church, he had another episode of substernal pain followed by radiation to the left chest, into the abdomen and into both inguinal regions Shortly thereafter he became nauseated and vomited Physical examination was essentially unchanged except for a rigid abdomen All signs and symptoms subsided within three days

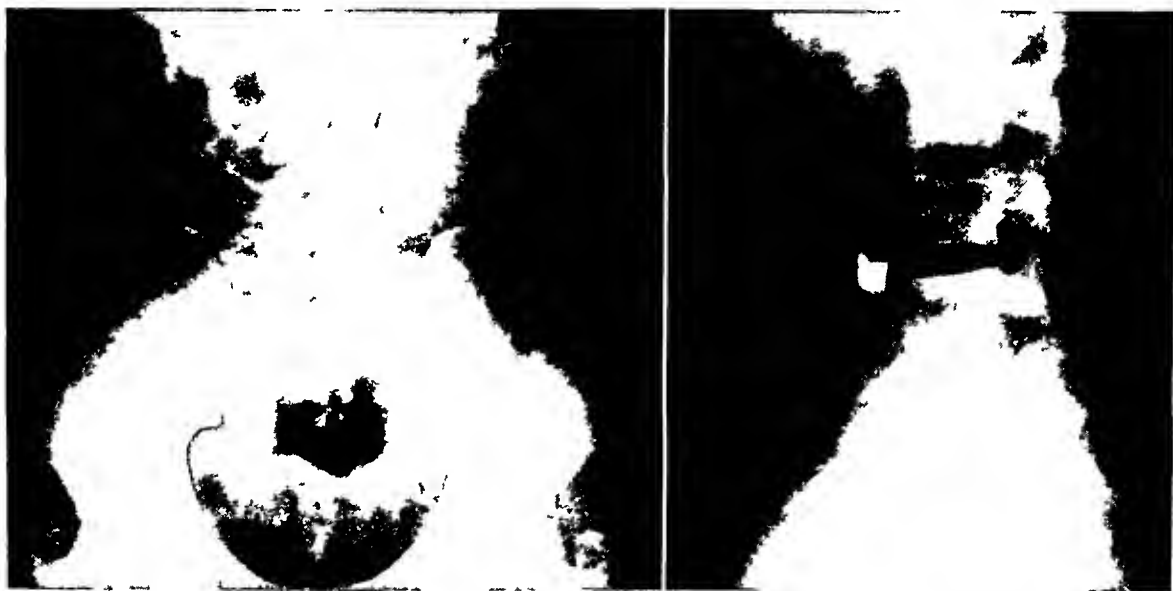


FIG 4—Roentgenograms of the abdomen with the foreign body at the bifurcation of the aorta

Since the patient complained of recurrent attacks of chest and abdominal pain, it was feared that the abdominal aorta was being eroded by the irregular foreign body and that eventual rupture of the vessel would occur This belief was partially substantiated by fluoroscopic examination which demonstrated motion of the foreign body and by the evidence of peripheral vasospasm in the lower extremities from irritation of the aortic wall An operation was planned in which an attempt would be made to remove the foreign body from the aorta

Operation—December 28, 1945 Under gas, oxygen, and ether anesthesia, a left paramedian incision was made The bifurcation of the aorta was exposed transperitoneally, with vertical incision of the posterior peritoneum just to the left of the midline The aorta was approximately one-half of its normal diameter and was tightly constricted about the foreign body A fusiform dilatation was present in this region, with partial erosion of the wall The common iliac vessels did not pulsate The aorta was mobilized below the inferior mesenteric artery and a small soft rubber tube placed beneath it The common iliac vessels were similarly mobilized with rubber tubing placed around them In view of the erosion of the vessel wall it was believed that removal of the foreign body with restoration of continuity of the vessel was not possible Bulldog clamps were placed on the common iliac vessels and the skin surface temperatures of the feet observed After a period of observation for 15 minutes during which the skin surface temperatures

did not change (Fig 5), the iliac vessels were doubly ligated with double-zero braided silk, transfixed, and divided

The vessels were found to be obstructed at the bifurcation by partially organized thrombus. The bullet was removed from the aorta (Fig 7). The lumen at the aortic bifurcation was filled with a partially organized thrombus which surrounded the foreign body and was firmly adherent to the intimal lining. Bleeding from the middle sacral artery was encountered when the thrombus was removed and was controlled by ligation of the vessel. The aorta was ligated immediately below the origin of the inferior mesenteric artery. This occlusion was accomplished by two ligatures of double-zero braided

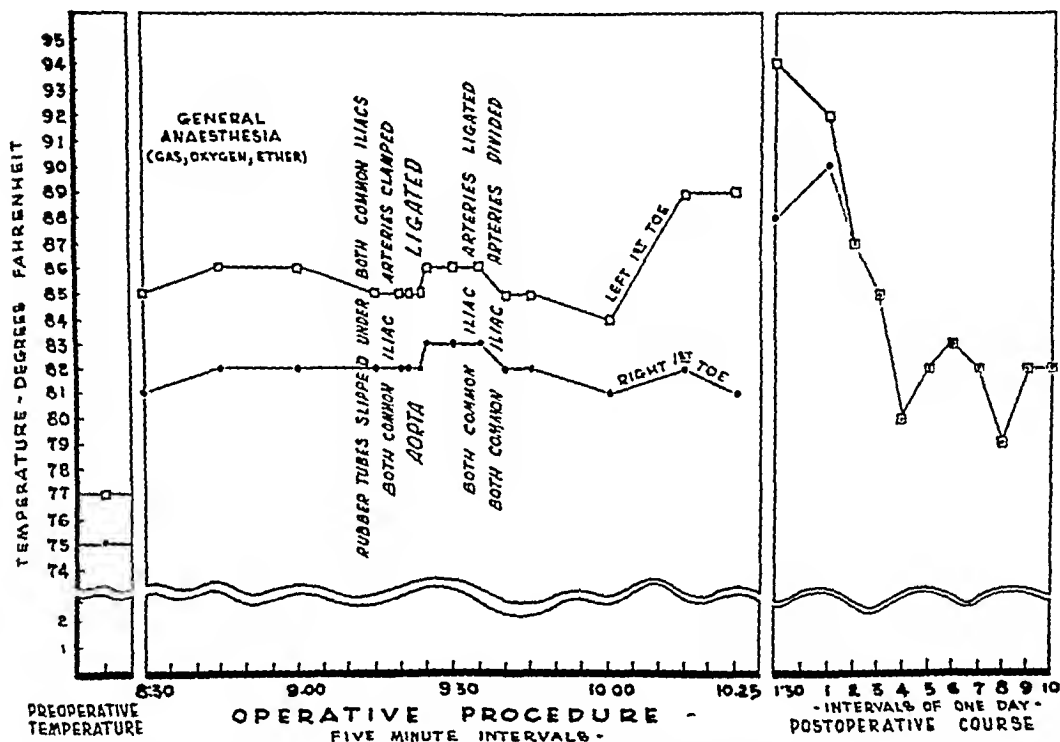


FIG 5—Skin-surface temperatures of the first toes during the operative procedure and for the ten days following operation

silk and a transfixion suture. A portion of the eroded aorta was removed (Fig 6). The posterior and anterior peritoneal incisions were closed with a continuous catgut suture. The abdominal wound was closed in layers with fine silk sutures. Skin surface temperatures of the first toes were recorded every five minutes during the operative procedure.

Postoperatively, the skin surface temperature of the feet were observed as charted (Fig 5). Sympathectomy or sympathetic blocks were not considered necessary. Anticoagulants or drugs for vasodilatation were not used. Skin resistance determinations were normal postoperatively confirming the presence of normal sympathetic innervation of the lower extremities.

During the first three postoperative days oral temperatures varied from 99° to 100° F. During this period the skin surface temperatures of the first toes remained abnormally high. These findings demonstrated a normal vasomotor response in the extremities to elevation of general body temperature. These temperatures returned to normal levels on the 4th postoperative day, when the fever subsided. Temperature recordings were made daily for ten days after operation.

The response of the skin surface temperatures of the first toes to changes in environmental temperature was determined on the 65th postoperative day. The patient was exposed, with all clothing removed, in a constantly controlled temperature room for 30 minutes before the test was begun. The temperature of the room was maintained at 76° F for one hour as control and readings were recorded. The temperature was then lowered to 64° F (cold room) for one hour, temperatures were recorded at ten-minute intervals. The room was then heated to 85° F (warm room) for one hour, and responses in skin temperature of the first toes were recorded as shown in Figure 8. Change from the 76° F level of the room to 64° F was completely effected within ten minutes.



FIG 6—Artist's conception of the operative procedure. The foreign body had been removed and a portion of the injured aorta excised. An additional segment of the damaged aorta is being excised.

Similarly the change from 64° F to 85° F was attained within ten minutes. The temperature levels of the normal, cold, and warm environments were constant. The humidity was controlled at low saturation levels.

Subsequent Course—It can be seen from the variations in skin surface temperatures that the normal vasomotor mechanism has remained sufficiently labile to insure the patient a tolerance for environmental change in temperature. Both lower extremities responded similarly to the changes.

Five months after operation the oscillometry and skin surface temperatures of the

extremities were again determined (Fig 3) It can be seen that at the time of the initial examination the occlusion of the aorta was not complete, the complete obliteration of its lumen probably occurred at the time of the severe abdominal pain 20 days prior

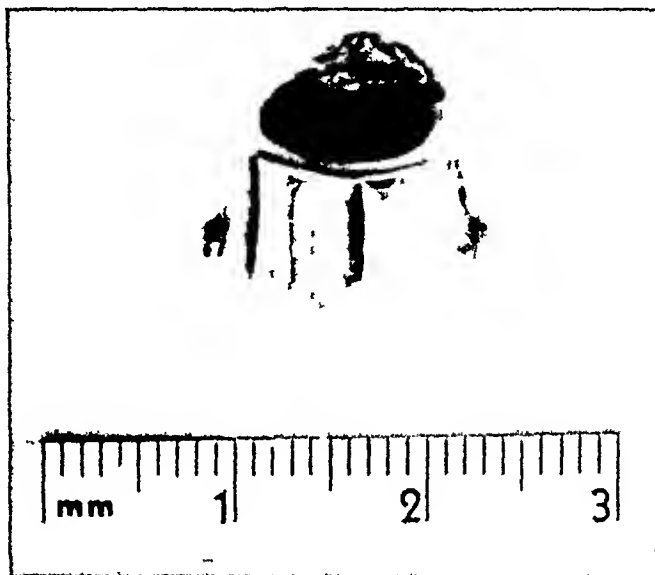


FIG 7—The foreign body removed at operation
Multiple irregular projections are present

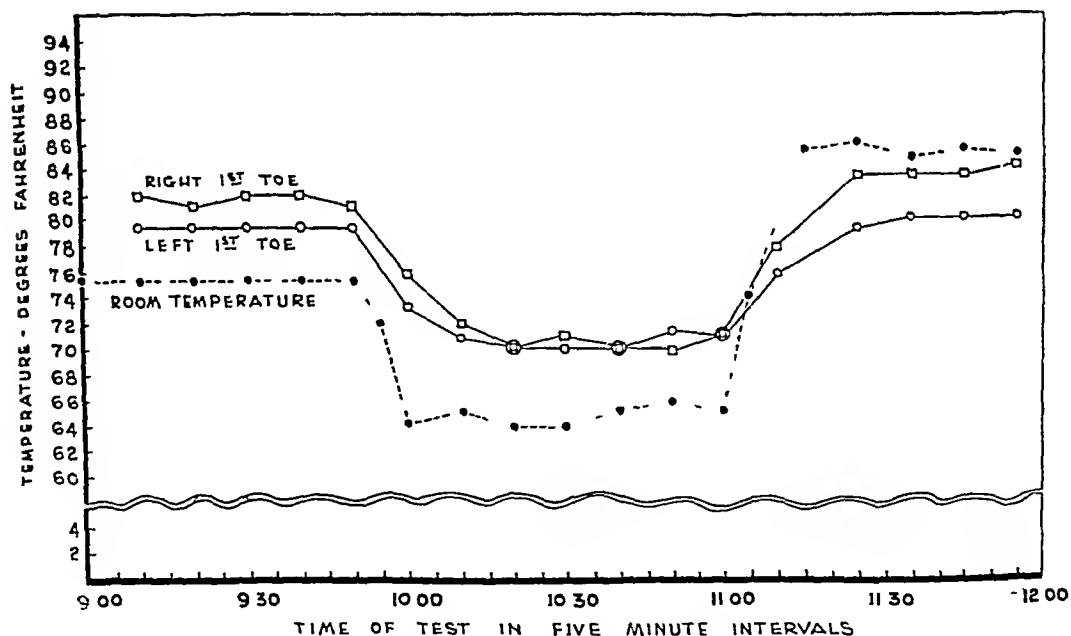


FIG 8—Skin surface temperature studies of both first toes in constantly controlled room at normal, cold, and warm levels 65 days following ligation and division of descending aorta and both common iliac arteries

to operation At the end of five months the formation of adequate collateral circulation is shown by the greater skin surface temperatures in both lower extremities at levels well above the normal, as compared with subnormal readings preoperatively This is particularly significant since the oscillometry postoperatively is at levels indicative of major

arterial obstruction The decrease in pallor of the right foot on elevation and continued absence of pallor in the left foot on elevation further confirms the presence of improved collateral circulation Since the oscillometry had originally been less on the left it can be assumed that obliteration of the common iliac of that side occurred first, and that a greater period had elapsed for the establishment of collateral channels

The patient believed that he had been benefited by operation He stated that he was able to walk greater distances without tiring and that he had had no recurrence of the abdominal or chest pain

The conditions present in this case gave an ideal sequence leading to ligation of the aorta The patient was young with the vascular elasticity of youth Occlusion of the aorta was not sudden but progressed over a period of several weeks, with variations in the completeness of obstruction to blood flow Finally, at the time of operation, the vessel had become completely occluded with an adequate collateral circulation established Operation in this instance, actually, immediately improved the circulation in the legs as manifested by the prompt rise in skin surface temperatures of the toes (Fig 5)

The immediate rise in skin surface temperatures of the toes, after the aorta had been ligated with the subsequent greater postoperative elevation, is probably accounted for on the basis of relief from the reflex vasoconstriction of the distal arterial bed (Leriche and Werquin¹³) produced by the constant trauma and irritation of the arterial wall and periarterial sympathetic plexus by the irregular foreign body

It has been stressed by Brooks,¹⁰ that absence of pulsations in the femoral arteries is indicative of adequate collateral channels for blood supply to the lower extremities in the presence of an aneurysm of the abdominal aorta Brooks,^{10, 11} Blalock and Johnson^{10, 11, 12} have also shown that such a ligation of the abdominal aorta places no additional strain upon the heart by increased peripheral resistance, which one would suppose to follow obstruction of that vessel It was shown by them that the cardiac output is decreased and that there is little change in the blood pressure in the artery proximal to the occlusion

The collateral circulation probably develops through the anastomoses of the inferior mesenteric with the inferior hemorrhoidal arteries, the inferior epigastric artery with the superior epigastric artery, and, through the two lower lumbar and iliolumbar arteries with the internal iliac arteries The anastomoses of the lumbar, iliolumbar, and internal iliac arteries were excellently demonstrated by Morton and Scott⁴ in a case of ligation of the aorta by injection of a radiopaque liquid latex mass at the time of autopsy seven months after partial ligation of the aorta

It has been the common practice to use a broad cotton tape, rubber or metallic bands for occlusion of the aorta ^{2, 4, 5, 6, 7, 15, 16, 17, 18} It has been stressed by Holman¹⁴ that with ligation of the vessel in continuity the maximum force of each arterial pulsation is concentrated at the site of ligation, whereas, following ligation and division the force of each pulsation is dissipated by expansion and elongation of the thickened, retracted proximal seg-

ment with less strain at the point of ligation. Erosion of the arterial wall with subsequent partial restoration of the lumen of the vessel or rupture^{4, 5} frequently follow ligation without division, even though large ligatures are used. In the case reported, occlusion of the vessel was accomplished with double-zero braided silk ligatures followed by complete division of the aorta. It is believed that with ligation and division of the large vessels, ligatures of small size may be used with safety.

SUMMARY AND CONCLUSION

- 1 Thirty-six cases of partial or complete ligation of the abdominal aorta appear in the literature, with 12 of these cases successful.
- 2 An instance of ligation and excision of a portion of the abdominal aorta for a metallic embolus from the heart is presented.
- 3 Postoperatively, the distal vascular bed was relieved of vasospasm produced by the foreign body.
- 4 The lower extremities reacted normally to changes in environmental temperature after aortic division.
- 5 Collateral circulation developed rapidly with increase in tolerance for exercise.
- 6 Sympathectomy or sympathetic blocks were not considered necessary.

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ONE-STAGE RESECTION AND ANASTOMOSIS OF THE COLON

UTILIZING THE FURNISS CLAMP

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THE PENDULUM OF SURGERY of the large intestine has returned to its starting point. Modern writers again advocate colon resection with primary anastomosis and without complementary colostomy. It is our purpose to discuss the reasons for this trend and to present a technic of resection and anastomosis which has produced satisfactory results.

The first reported resection of the colon was performed by Reybard²⁸ in 1833. He chose end-to-end anastomosis as the most logical means of re-establishing continuity of the intestine. His patient, like the second case reported by Thiersch³⁰ in 1875, died of peritonitis. It was not until 1881 that a successful case was recorded by Kohler¹⁶. In 1889, Billroth³ analyzed 17 cases, with the forbidding mortality of 60 per cent. It is not surprising therefore, that when von Mickulicz³¹ reported 24 operations for resection of the colon by means of the exteriorization method that bears his name, with a mortality of only 16.6 per cent, surgeons hailed this method as a great modern advance in surgery of the colon. Von Mickulicz³¹ did not claim originality for this procedure. In one of his early papers he refers to the work of Bloch⁴ in 1892. Traditionally, Paul²⁵ has also been given credit for having independently utilized the operation in 1895. However, it is not generally known that Heinecke¹¹ wrote of the exteriorization method in his "Vorlagerung und Extraperitoneal Resektion" two years before Bloch.¹⁴

The multiple-stage exteriorization operation, or one of its modifications, has been the operation of choice for resection of the colon at all levels, excluding the rectum. As experience grew, certain disadvantages became apparent. Multiple operations, with the accompanying multiple operative risks, are necessary. In addition, there is a high incidence of complications, such as wound disruption, wound infection, persistent fistulae, and postoperative herniae. Convalescence and hospitalization are prolonged. The artificial anus, although temporary, is an annoyance. In order to create adequate spur there may be a tendency to save colon and its mesentery and, thereby, to jeopardize the efficacy of the cancer operation. The danger of local implants of carcinoma on the abdominal wall has largely been abolished by the obstructive resection of Rankin²⁶. However, this operation requires temporary complete obstruction of the colon.

Proponents of multiple-stage colonic surgery state that the low mortality possible with this operation outweighs its disadvantages. Rankin^{26, 27}, Lahey,¹⁷ Cheever,⁵ in 1931, reported comparable series of cases and showed that in their hands, one-stage resections, with anastomosis and a proximal vent for decompression, had a lower mortality than the exteriorization

procedures Harvey,¹⁰ Wilkie,³⁶ MacFee,²¹ Finsterer,⁷ Joll,¹² Gibbon and Hodge,⁹ and Stone and McLanahan²⁹ gave similar statistics. According to Gibbon and Hodge, the combined mortality of their cases and those of MacFee,²¹ Wilkie,³⁶ and Stone,²⁰ representing 246 primary aseptic colonic resections, some with and some without a proximal vent, was 14 per cent. Coin-

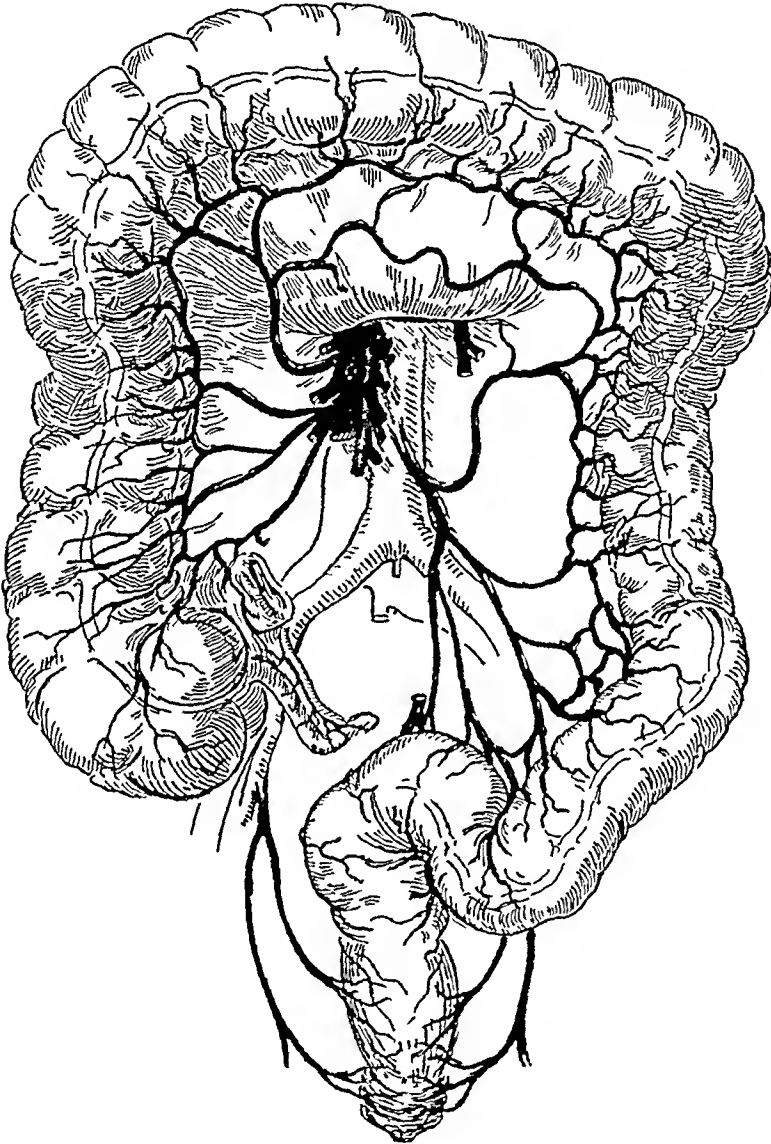


FIG 1—Blood Supply of the Colon (after Jones and Shepard)¹³ Right colic artery supplies terminal ileum and caecum through ileocolic branch. Ascending colon supplied by secondary right colic branches. Marginal anastomotic branch meets branch from middle colic at hepatic flexure. Middle colic artery supplies hepatic flexure, and transverse colon, gives off long anastomotic marginal artery which together with branch from left colic artery supplies entire transverse colon and a portion of the hepatic flexure. Left colic artery supplies splenic flexure and descending colon. Two or three sigmoidal arteries given off by the inferior mesenteric supply the sigmoid colon. The continuation of the inferior mesenteric is called the superior hemorrhoidal, this supplies the rectosigmoid. The middle and inferior hemorrhoidal come off the hypogastric artery. Note the poor blood supply on the anti-mesenteric border of the intestine and the absence of anti-mesenteric border anastomoses.

cident with the introduction of the Miller-Abbott tube for decompression in resections of the right colon, and the use of intestinal chemotherapeusis, this mortality has been reduced further. White and Amendola³⁵ report a mortality of 11 per cent, Babcock^{1, 2} 9.4 per cent, Meyer, *et al*²³ 5 per cent, Waugh³⁴ 4 per cent, and Wangenstein^{32, 33} 1.7 per cent.

Most writers agree that a proximal colostomy or ileostomy is not necessary in the patient who is not suffering from obstruction, Harvey,¹⁰ Mayo and Simpson,²² Stone and McLanahan,²⁹ Wangenstein,^{32, 33} Waugh,³⁴ Meyer, *et al*²³. Others, Babcock,^{1, 2} and Dixon,⁶ continue to recommend a proximal vent. Generally, it is believed that an aseptic anastomosis is desirable, although Meyer²³ has recently reported a series of 20 open anastomoses, with a mortality of only 5 per cent.

TABLE 1

Resected Section	Diagnosis	No of Cases	Complications (Abdominal)	Age Range	Average Age	Range P O Days	Average P O Days	Mortality
Terminal ileum cecum ascending colon hepatic flexure	Adeno carcinoma (5) Regional enteritis (7)	12	1 Intestinal ob- struction requir- ing ileostomy 2 Paralytic ileus, intubated	27 to 57	43	7 to 30	18	0
Transverse colon	Adeno carcinoma Ulcerative colitis	1	0	25	25	19	19	0
Splenic flexure	Adeno carcinoma	5	1 Peritonitis ab- scess fecal fistula	37 to 66	50	9 to 76	29	0
Descending colon	Adeno-carcinoma	1	0	68	68	13	13	0
Sigmoid	Adeno carcinoma (5) Chronic colitis (1)	7	0	37 to 76	49	8 to 28	15	One on 5th P O day pulmonary embolus
Totals		26	11 5%	27 to 76	42	7 to 76	19	3 8%

We are reporting a series of 26 consecutive colonic resections, covering all regions of the colon above the peritoneal reflection, which were done in one stage without a proximal colostomy or ileostomy, and anastomosed aseptically with the Furniss clamp, with a mortality of 3.8 per cent (Table I). The one fatality occurred with the dramatic suddenness of a pulmonary embolus on the fifth day, while the patient, ambulated early, was returning from the lavatory. There were three abdominal complications in this series (Table I). Two patients obstructed postoperatively, one required intestinal intubation and the other an ileostomy. A third patient developed peritonitis, an intraperitoneal abscess and a fecal fistula due to a faulty anastomosis. This patient was hospitalized for 76 days.

The postoperative hospital stay of this group of patients varied from 7 to 76 days, and averaged 19 days.

ONE-STAGE ANASTOMOSIS OF COLON

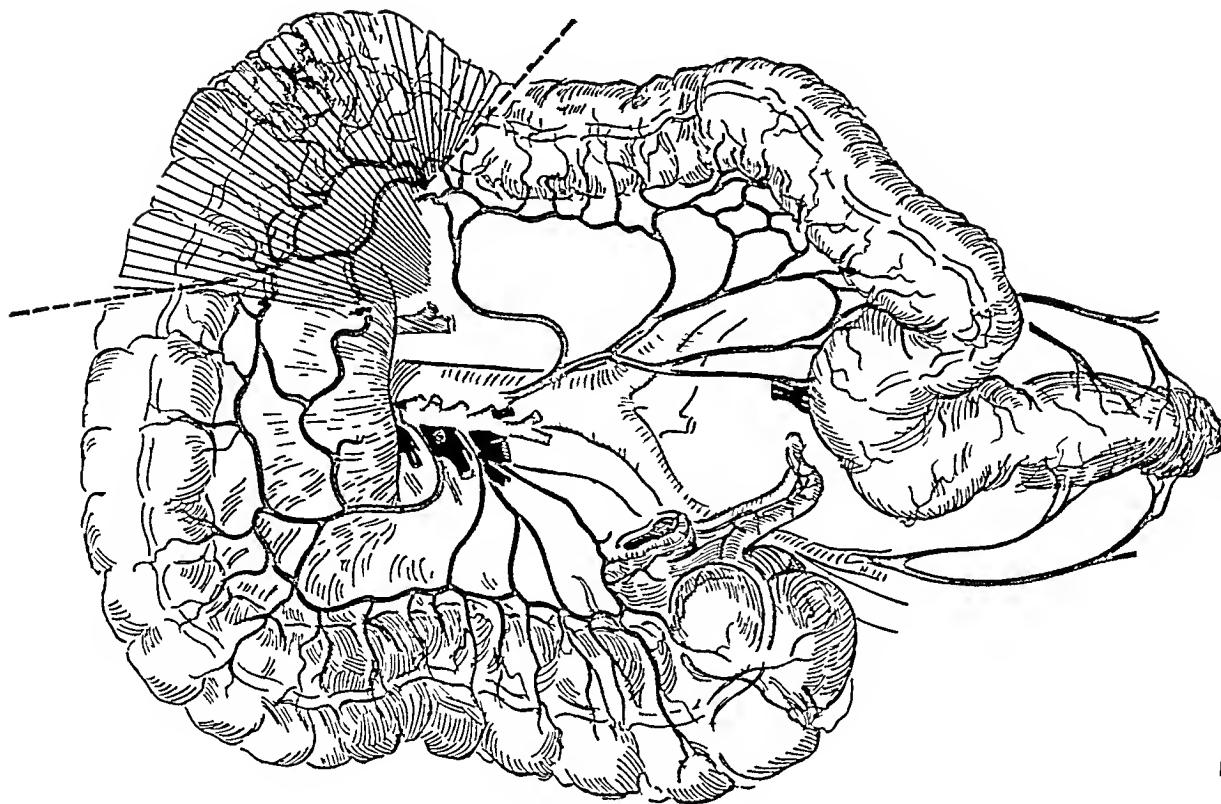


FIG 3—Resection of Splenic Flexure Branches of middle colic and left colic arteries ligated Main arteries preserved Note section of intestine at 45 degree angle to insure blood supply at anti-mesenteric border

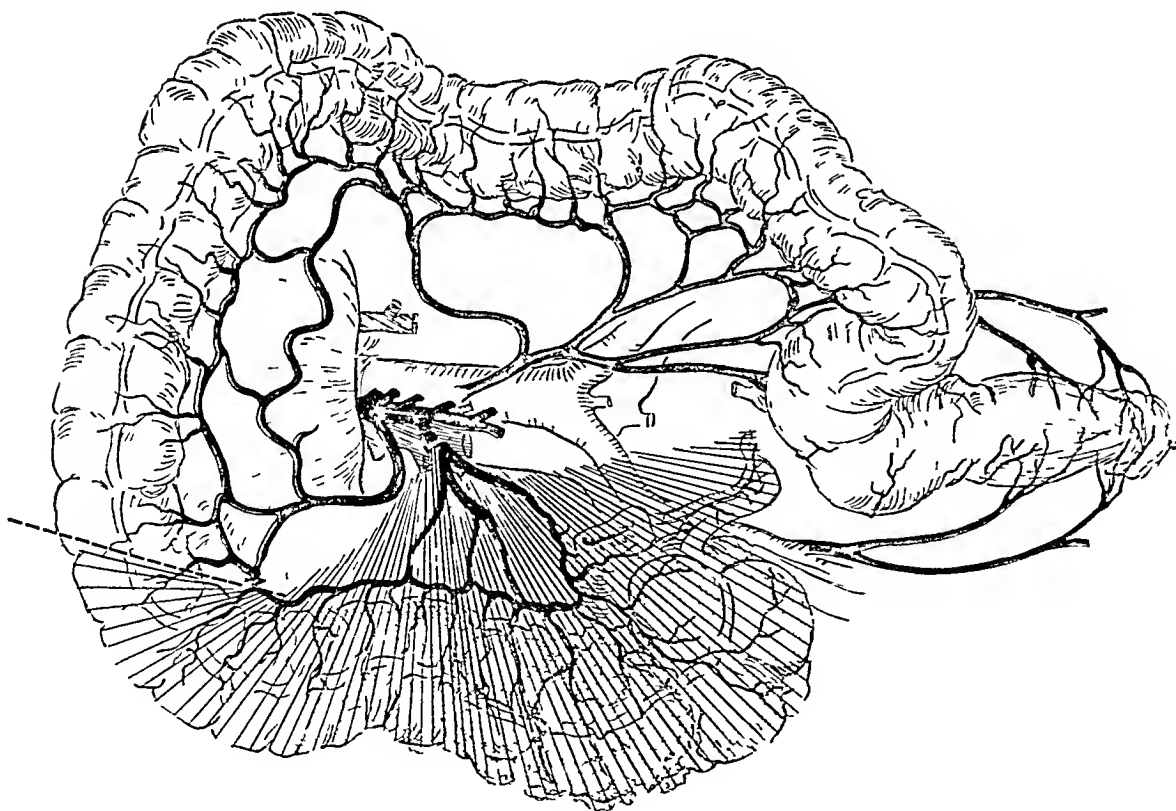


FIG 2—Resection of Right Colon Terminal ileum, caecum, ascending colon and hepatic flexure removed Right colic artery ligated, middle colic artery preserved Note section of intestine at 45 degree angle to insure blood supply at anti-mesenteric border

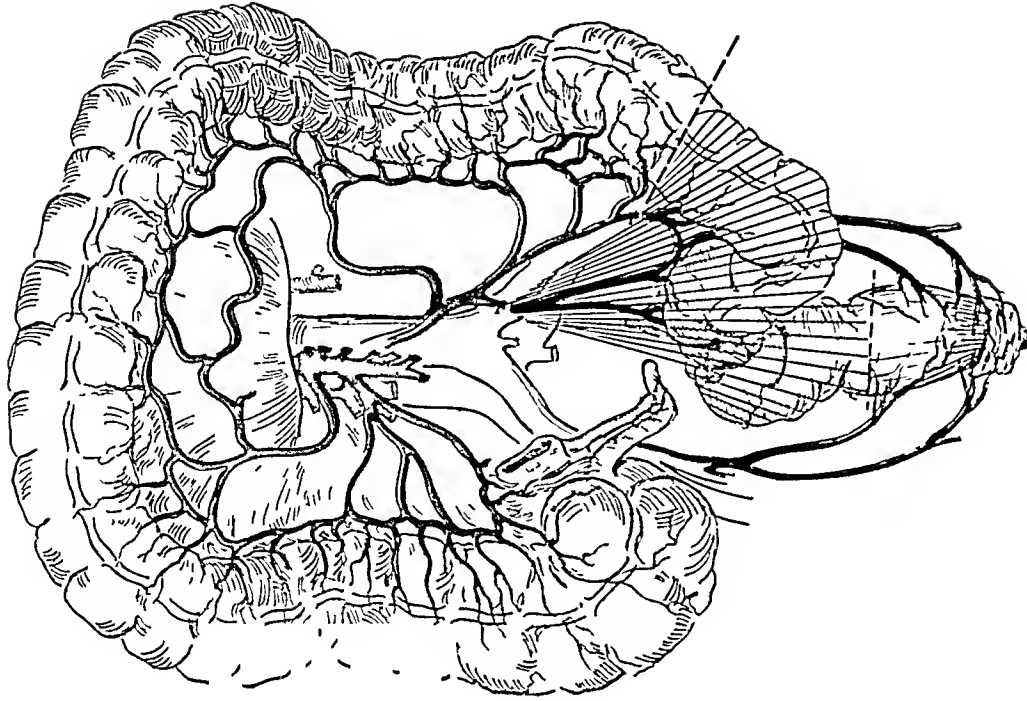


FIG 5.—Resection of Recto-Sigmoid Upper sigmoidal artery preserved Superior hemorrhoidal artery ligated Middle and inferior hemorrhoidal arteries preserved

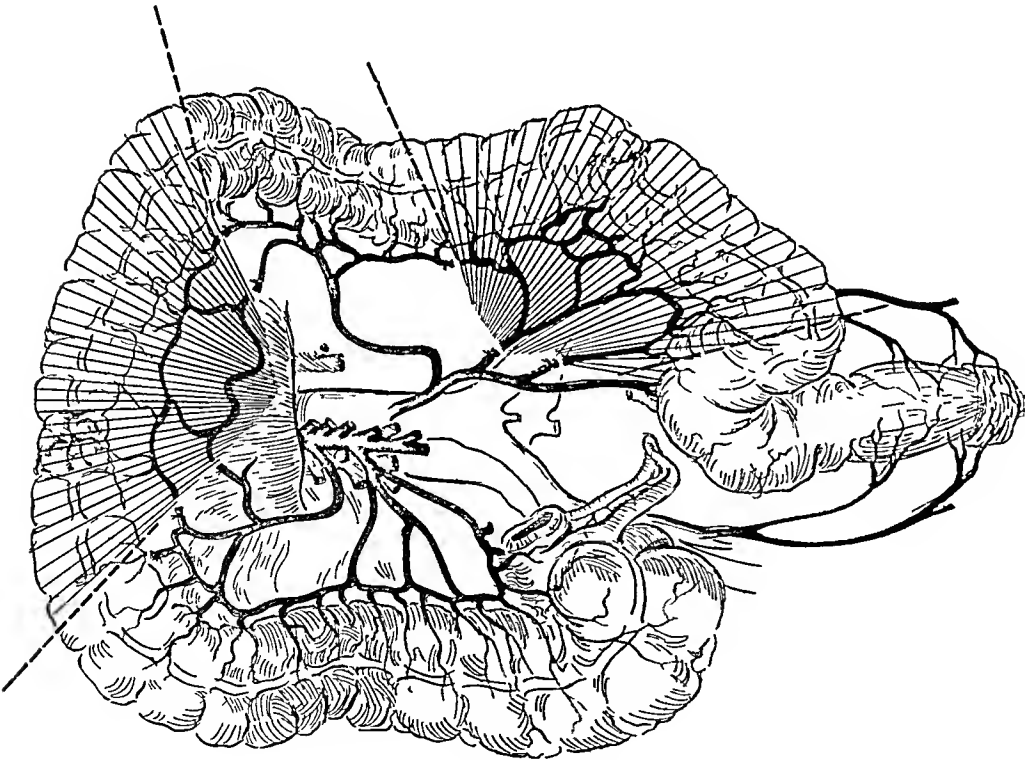


FIG 4.—Resection of Transverse Colon Left colic and middle colic arteries preserved
Resection of Sigmoid Colon Sigmoidal branches of inferior mesenteric artery ligated Superior hemorrhoidal artery and marginal artery of left colic preserved Note section of intestine at 45 degree angle

Careful selection, adequate pre- and postoperative treatment, and attention to details are prerequisites for success in this field of surgery. Only nonobstructed patients are selected for this procedure. The obstructed patient is not a candidate for one-stage resection and anastomosis without a proximal vent. He is first treated for intestinal obstruction by appropriate medical and surgical decompression.

Five to seven days are allowed for preoperative preparation. During this period, aberrations are corrected in fluid and electrolyte balance, anemia, hypoproteinemia, and vitamin deficiencies. In addition, vigorous attempts are made

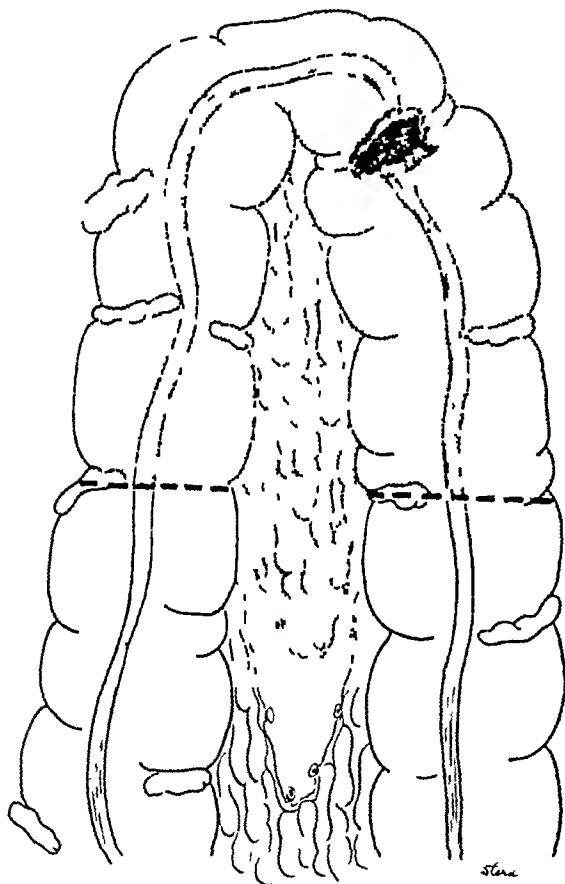


FIG 6—Colon prepared for application of clamp

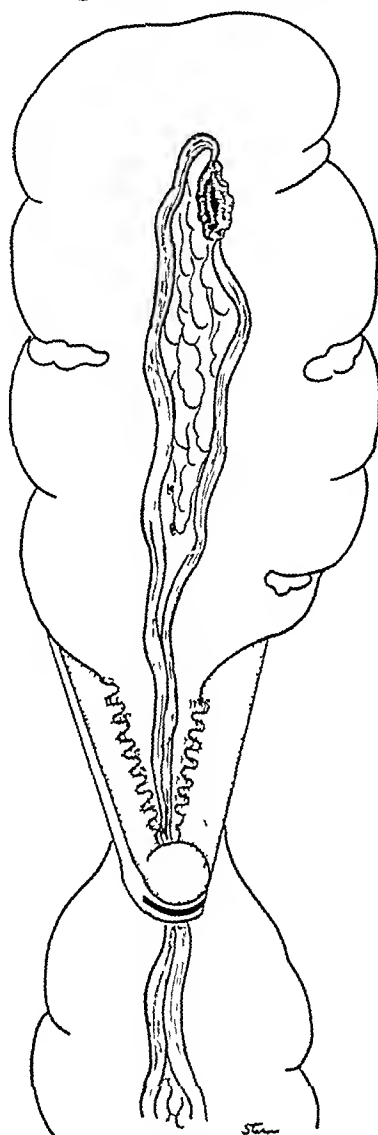


FIG 7—Limbs of colon rotated medially. Clamp applied at 45 degree angle to anti-mesenteric border

to replenish the stores of tissue proteins. Our patients receive per day, 2,000 cc of amigen, 500 mg of ascorbic acid, and 200 mg of vitamin B-complex parenterally. Anemia is corrected by transfusion of whole blood. The patient is placed upon a high protein, low residue, diet. Purgings with magnesium sulphate is carried out for the first two days of preoperative preparation. Throughout the period the patient receives 12 Gm of succinylsulfathiazole.

per day At operation, the colon will be found collapsed and free from fecal material

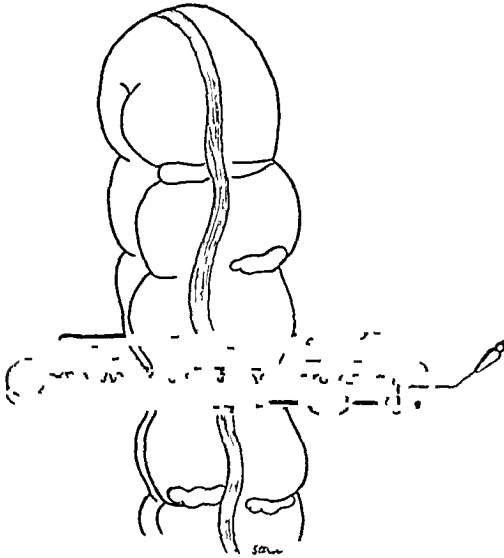


FIG 8—Furniss clamp applied Specimen ready for excision

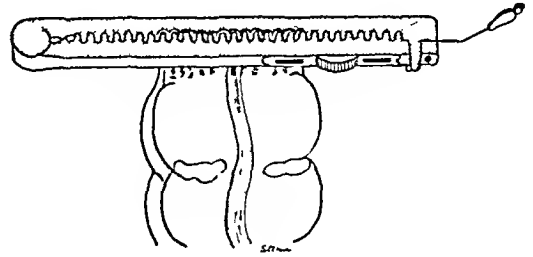


FIG 9—Specimen removed Limbs of intestine held firmly by clamp and pin

According to Kerr,^{14, 15} about 250 methods of intestinal anastomoses have been reported Of these methods, about 45 are aseptic or nearly aseptic We have chosen to perform aseptic anastomosis of the colon because we feel that in spite of chemo-

therapeutic antiseptics of the colon, modern surgical thought dictates that contamination, no matter how innocuous, be kept to a minimum The method of anastomosis which we have found useful was first described by Furniss⁸ in 1934, and utilizes a clamp that retains the soundness of the

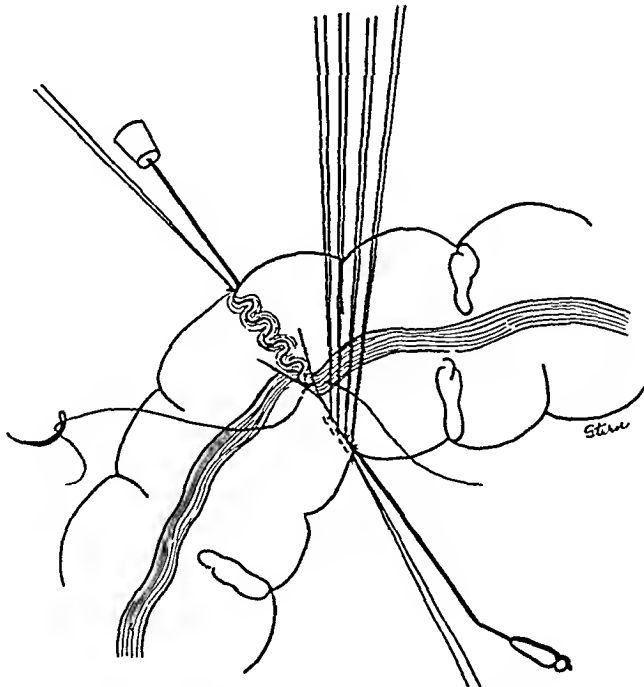


FIG 10—Stay sutures placed before removal of clamp Limbs to be anastomosed, held by pin First anterior row of interrupted Lembert sutures placed

ONE-STAGE ANASTOMOSIS OF COLON

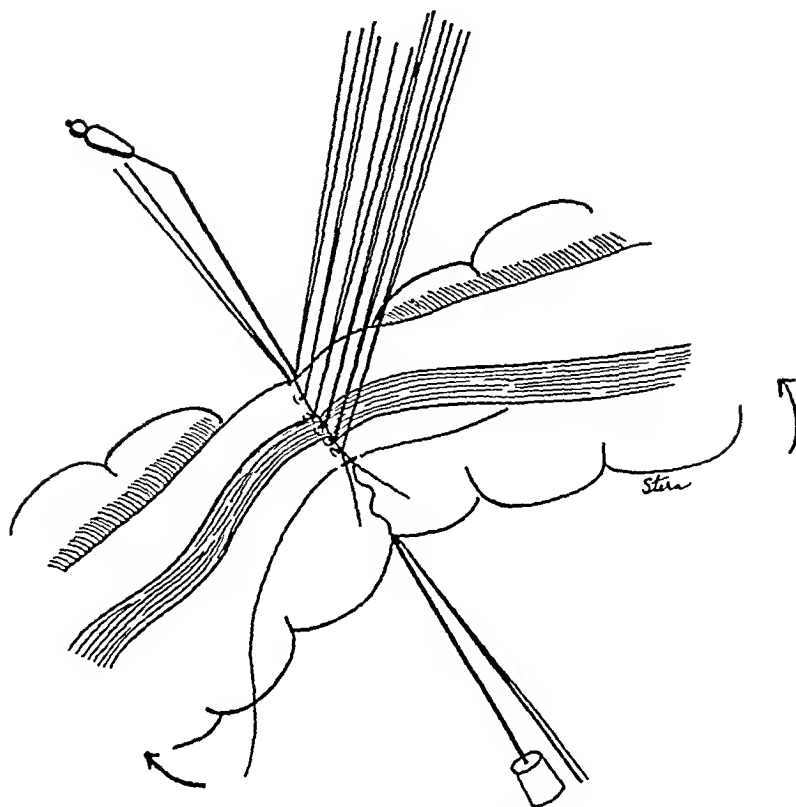


FIG 11—First anterior row complete Colon rotated by turning pin clockwise or counter-clockwise First posterior row of Lembert sutures placed

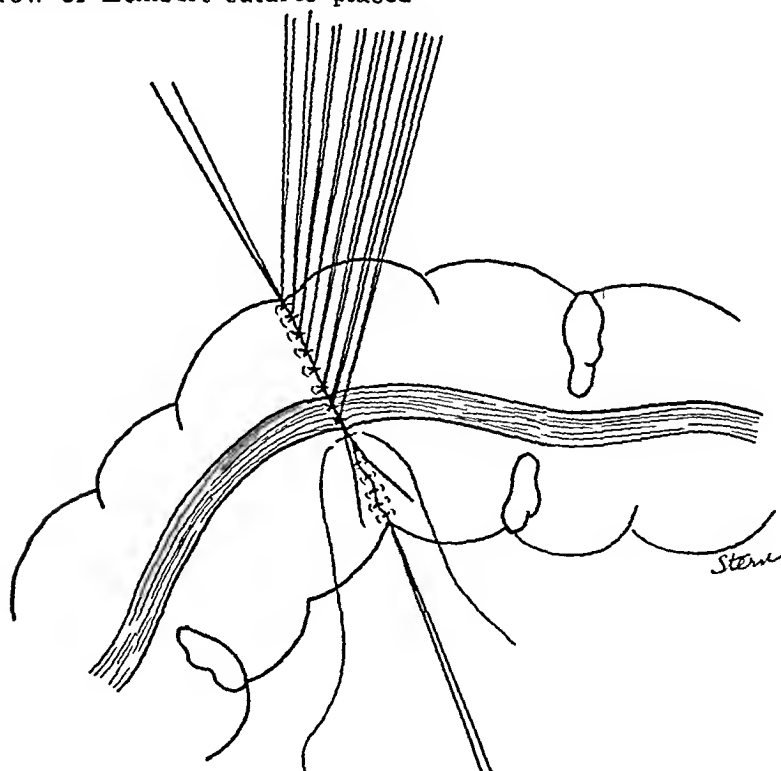


FIG 12—Pin removed Second posterior row of Lembert sutures placed

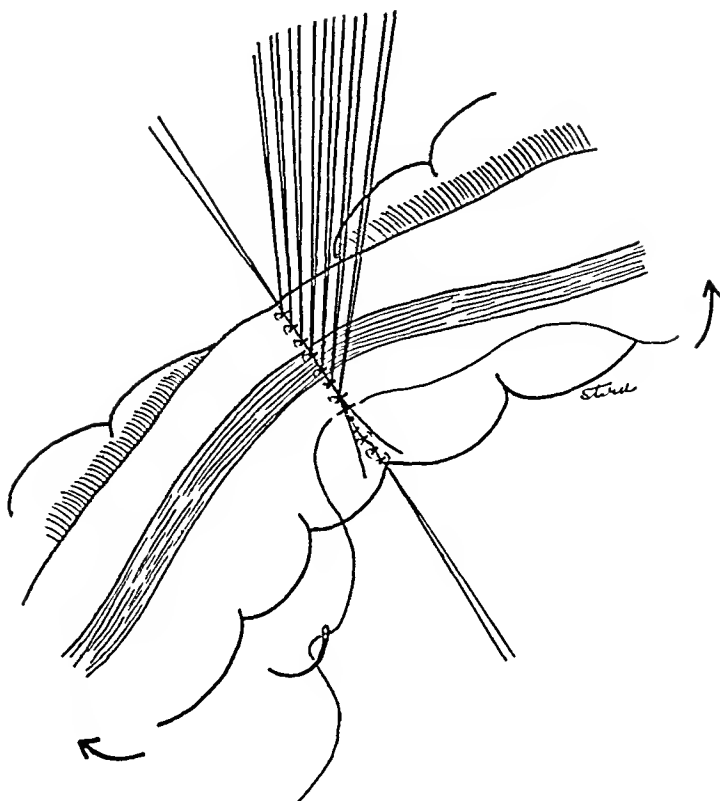


FIG 13—Colon, rotated back to normal position Second anterior row of Lembert sutures placed

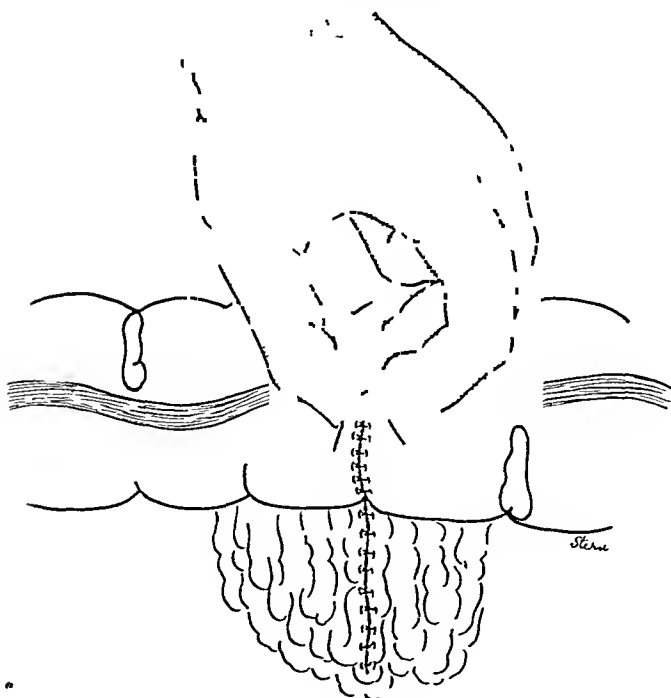


FIG 14—Diaphragm opened by manipulation and patency of anastomosis tested Defect of mesentery repaired by interrupted sutures

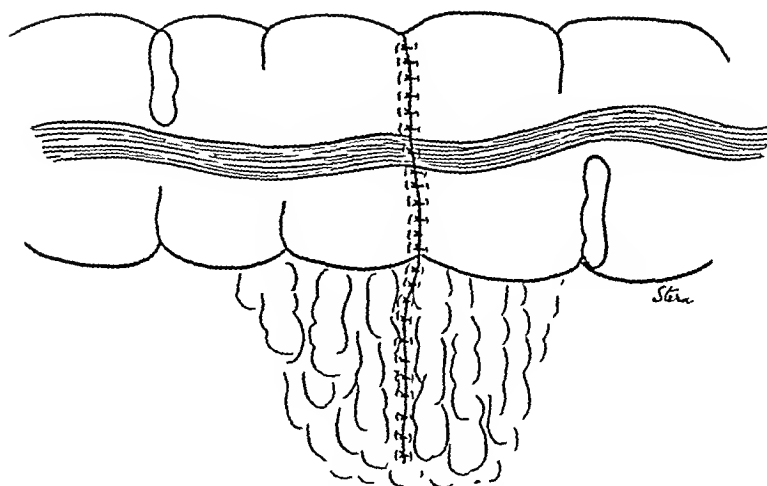


FIG 15 —Complete anastomosis

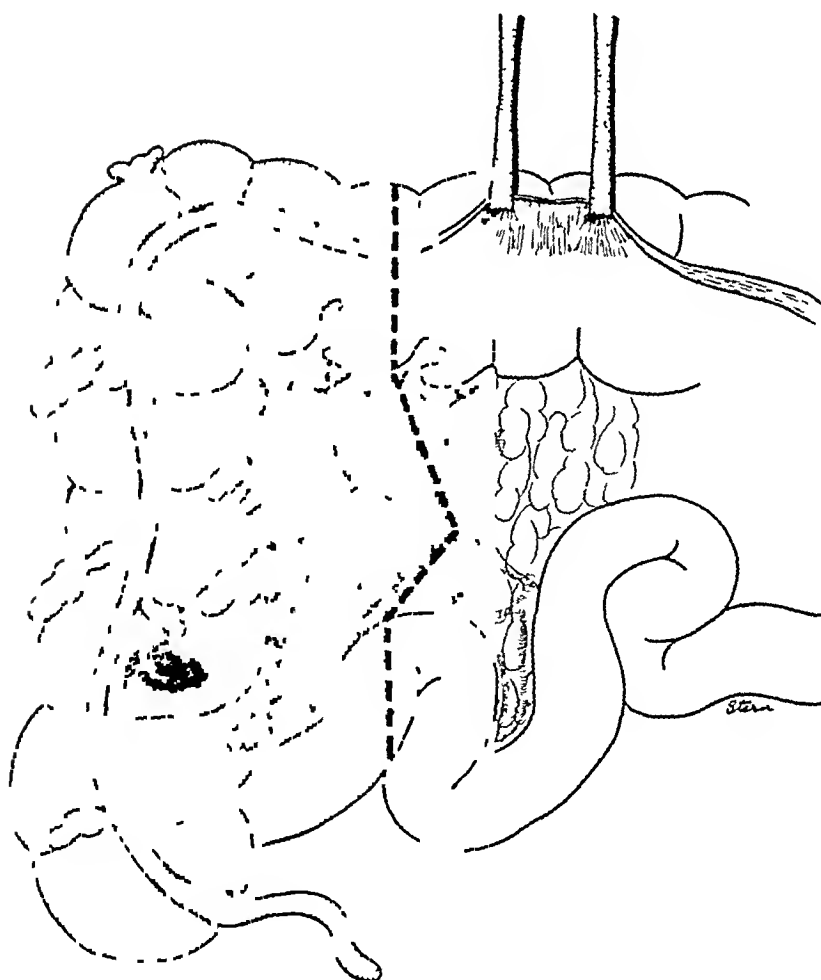


FIG 16—Illustrated area to be excised Allis clamps placed on taenia, raising a tent of all layers of the transverse colon

Parker-Kerr²⁴ basting stitch but simplifies the technical steps of the procedure. Furniss⁸ advised the use of two clamps for anastomosis of the colon. He felt that because of the thickness of the wall, a single clamp would not give adequate pinning. The McClure²⁰ modification of the Furniss clamp corrects this deficiency of the original instrument, and only one clamp has been found necessary.

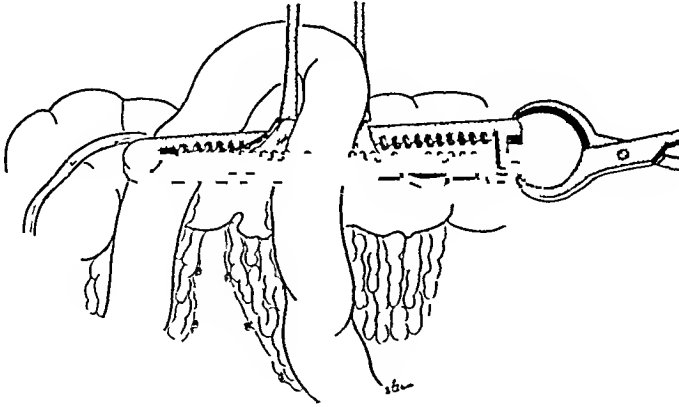


FIG 17—Furniss clamp placed to include tent of transverse colon and ileum. Distal ileum to be sacrificed, placed against tent of transverse colon at superior surface of clamp. Proximal ileum to be preserved at inferior surface of clamp.

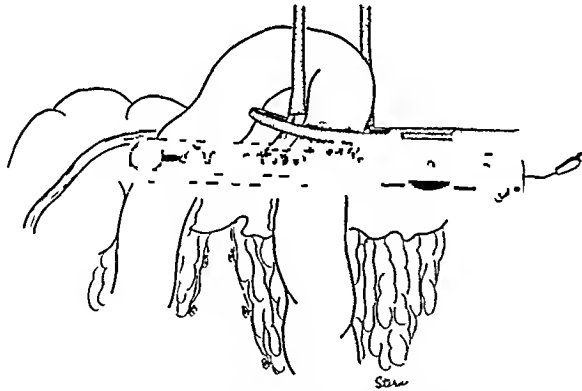


FIG 18—Furniss clamp locked and pin passed. Terminal ileum and transverse colon tent ready for excision.

The primary consideration of surgery of the colon is removal of the growth with the regional lymph nodes according to the dictates of good cancer surgery. In addition, the resection must be performed so that an adequate blood supply is available to the severed ends which will be opposed. Figures 1, 2, 3, 4 and 5 illustrate the anatomy of the blood supply of the colon, and the vessels that are preserved for resections at various levels. In 1917, Lockhart-Mummery¹⁹ emphasized that a safer end-to-end anastomosis could be per-

ONE-STAGE ANASTOMOSIS OF COLON

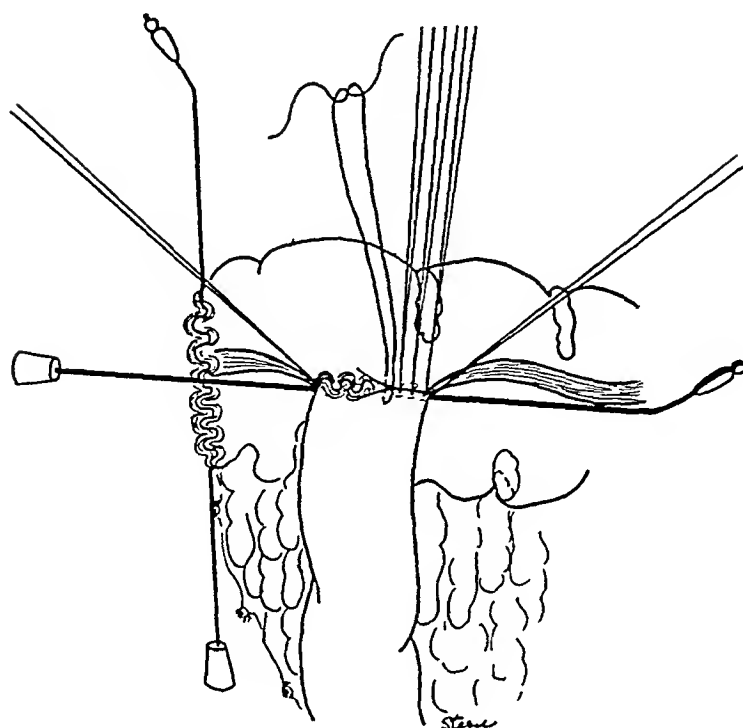


FIG 19—Guide sutures applied before removal of clamp Ileum pinned to transverse colon and first anterior row of interrupted Lembert sutures applied Specimen excised by placing second Furniss clamp across transverse colon Aseptic closure of blind end done with Furniss clamp

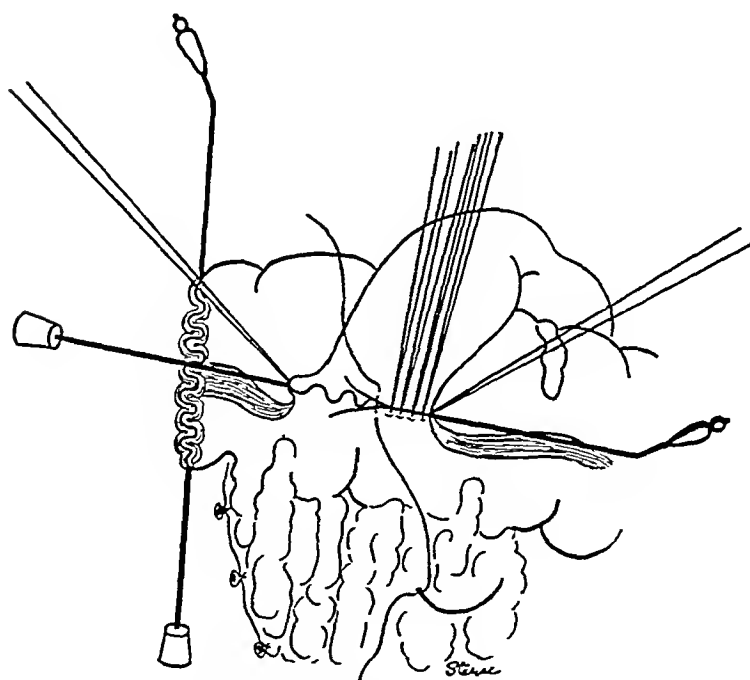


FIG 20—Ileum elevated and first posterior row of Lembert sutures placed

formed if the ends were cut at an angle of 45 degrees from the mesenteric border, due to the fact that the arteries to the antimesenteric tip of the bowel if cut at a 90 degree angle might be insufficient to maintain viability (Figs 3 and 4) Sealing of an anastomosis occurs by serosal union, hence, excess fat

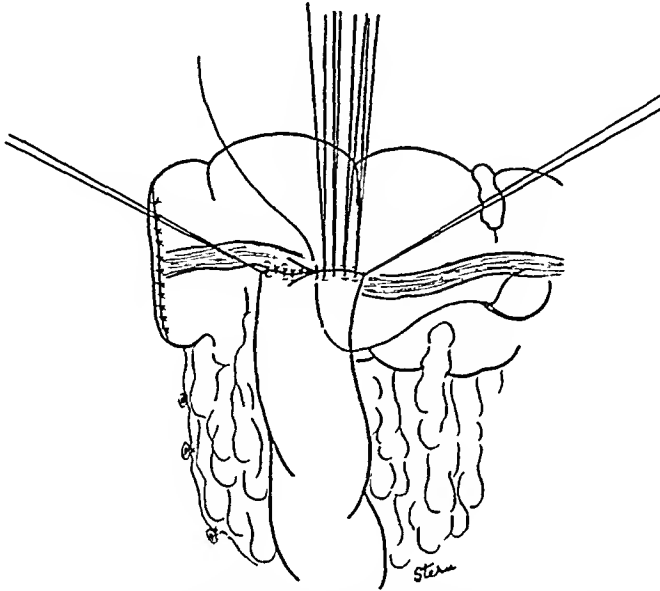


FIG 21—Second posterior row of Lembert sutures placed Stump of transverse colon closed with two rows of interrupted Lembert sutures

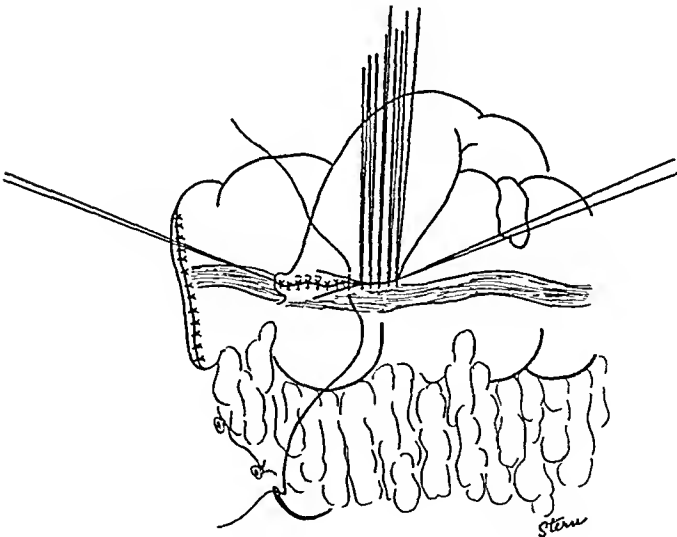


FIG 22—Second anterior row of sutures placed

and appendices epiploicae in the proposed line of suture are carefully removed before the clamp is applied

The segment to be resected is prepared with these considerations (Fig 6) in mind The bowel is rotated 90 degrees, the medial surfaces are opposed

and held with Allis clamps. The Furniss clamp is applied as shown in Figure 7. The clamp is locked, the pin passed, straight clamps are passed across the segment to be sacrificed (Fig 8), and the colon is resected flush with the Furniss clamp, using a knife moistened with pure carbolic acid (Fig 9)

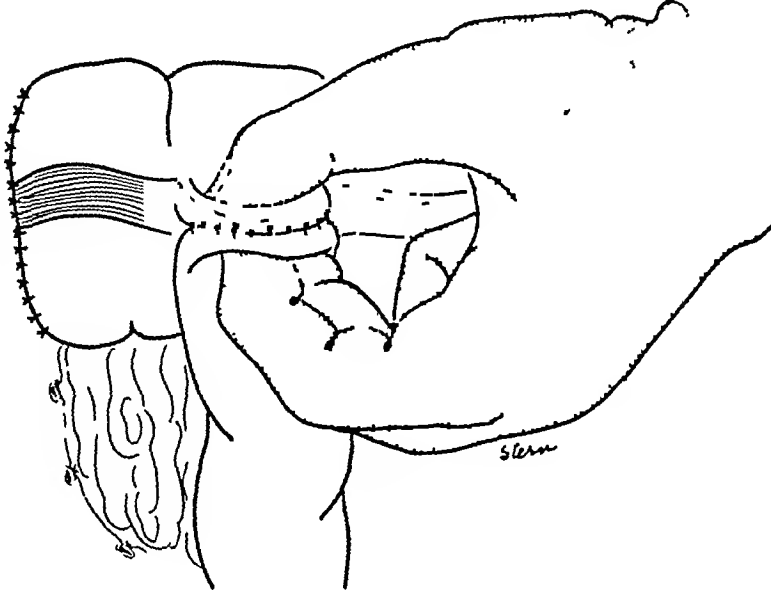


FIG 23—Diaphragm opened by manipulation. Patency of anastomosis checked

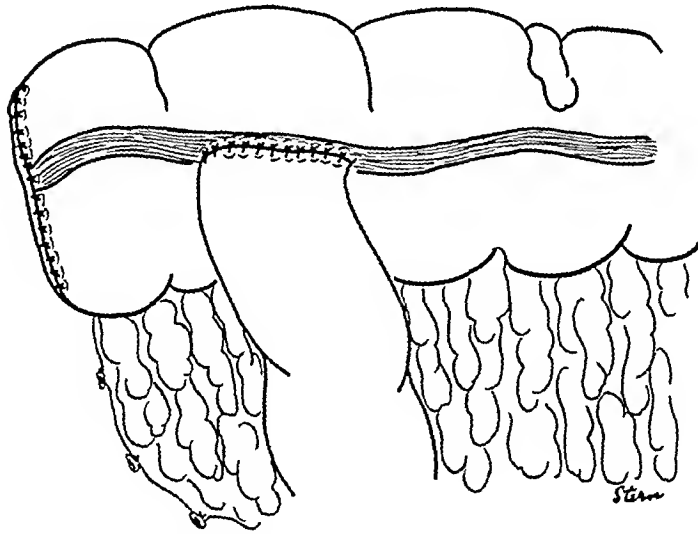


FIG 24—Completed anastomosis

The excess carbolic is removed with alcohol, and the colon is ready for anastomosis. Stay-sutures to take the tension from the intestine and prevent tearing, are placed at the mesenteric and antimesenteric borders, and the clamp removed (Fig 10). A single row of anterior cotton Lembert sutures is placed (Fig 10), the intestine is rotated, a posterior row of similar sutures is placed, and the pin is removed (Fig 11). A second row of interrupted cotton Lembert sutures is placed, and the mesentery repaired (Figs 12 and 13).

The diaphragm that has been formed by the clamp is opened by manipulation with the thumb and forefinger (Figs 14 and 15) Sutures are placed down to, but not through, the mucosa We believe that firmer, faster, and more accurate union is obtained with nonabsorbable sutures¹⁸ Interrupted fine cotton sutures are chosen for anastomosis, and for closure of the abdominal wall Drainage of the peritoneal cavity and wound has not been found necessary

The principle of resection and anastomosis of the right colon is the same although some of the technical steps are different An end-to-side anastomosis is performed The Furniss clamp is placed across the ileum and a tented portion of the transverse colon Care must be exercised to insure that the full-thickness of the wall of the colon is incorporated in the Furniss clamp This is best accomplished by drawing up a tent of transverse colon with Allis clamps that bite through all the layers (Figs 16, 17 and 18) The remainder of the technic is illustrated in Figures 19 to 24

A transfusion of whole blood is administered immediately postoperatively A Levine tube is left in the stomach, suction is not used Fluids are permitted by mouth, excess gastric residue siphoned off by the Levine tube Nutrition is maintained by infusion of amigen and glucose in distilled water Each liter of amigen contains 2.5 Gm of sodium chloride, and it is important, therefore, to prevent salt retention and tissue edema by supplying additional fluid as glucose in distilled water When the patient passes gas by rectum, the Levine tube is removed, parenteral feeding is gradually discontinued, and oral feeding gradually liberalized Low residue foods are usually tolerated and retained by the third day Cathartics, rectal tubes, and enemata are avoided The bowels move spontaneously between the third and fifth days Occasionally, it has been found necessary to stimulate the lower colon by means of glycerin suppositories All patients are ambulated on the first postoperative day, and daily thereafter They are urged to use the bathroom facilities rather than the bed pan Succinylsulfathiazole is used postoperatively

CONCLUSIONS

- 1 One-stage resection of the colon without proximal colostomy is a safe procedure for nonobstructing lesions
- 2 The mortality, morbidity, and hospital stay are reduced
- 3 Careful preoperative preparation, and attention to details of operative and postoperative treatment are essential for success
- 4 We have found that aseptic anastomosis with the Furniss clamp is a satisfactory and simple method

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AUTHOR'S NOTE Since the paper was submitted for publication, 24 additional cases have been done 21 for malignant lesions and 3 for benign lesions Intestinal complications of these cases 0, average age 51 years, average postoperative hospital stay 13.8 days, mortality 0 per cent

TOTAL CASES	COMPLICATIONS (ABDOMINAL)	AVERAGE AGE	AVERAGE P O DAYS	MORTALITY
50	6%	46	17	2%

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THE ARTERIAL SUPPLY OF THE DISTAL COLON PERTINENT TO ABDOMINOPERINEAL PROCTOSIGMOIDECTOMY, WITH PRESERVATION OF THE SPHINCTER MECHANISM

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THE ARTERIAL PATTERN of the colon has been a fundamental factor in determining the types of surgical procedures which can be successfully applied to that segment of the intestinal tract. In the surgery of the sigmoid and rectum the configuration of the arteries supplying these areas has been a particularly important consideration.

It would seem timely to correlate the design of the arterial supply of the sigmoid and upper rectum with the technic of abdominoperineal proctosigmoidectomy without colostomy and with preservation of the sphincter mechanism because of the increasing interest in this type of procedure. Moreover, Sunderland⁹ has recently added significantly to the many important studies of the arteries to the distal colon.

In the development of the present technic of abdominoperineal proctosigmoidectomy with preservation of the sphincter mechanism, extensive precautions have been taken to insure the viability of that portion of the colon which is brought down to the perineum. The feasibility of the operation was first established in animals. In 71 cadavers the vascular supply of the colon and rectum and the mobilization and transplantation of the viable bowel to the anus were proven to be practicable. In every operative case the pattern of the inferior mesenteric artery and its branches was noted by transillumination before any vessels were ligated.

The arterial supply to the segment of the bowel to be transplanted to the anus was observed by the same means after ligation of the inferior mesenteric artery. The distal point of viability was marked with a black silk suture, which facilitated its identification during the perineal phase of the operation. The distal point of viability was brought seven centimeters outside the anus. Viability was further assured by incising small vessels in the mesentery of the bowel and noting free bleeding.

This experience with abdominoperineal proctosigmoidectomy with preservation of the sphincter mechanism in 264 cases (from a total of 407 colon resections) may be considered to have been a method of study of the arteries to the sigmoid and upper rectum. As such, it can be integrated with the experimental anatomic studies.

Sudeck,⁸ in 1907, found that the vessels of the rectum became filled with injected material from the inferior mesenteric artery by transversing the

marginal artery when a ligature was placed on the superior hemorrhoidal artery above the origin of the last branch to the sigmoid. If a ligature were placed below the origin of the lowest sigmoidal artery, few, if any, of the rectal vessels filled. In maintaining adequate blood flow to the rectum when the superior hemorrhoidal artery had to be ligated, the origin of the lowest sigmoidal artery became known as the critical point of Sudeck. Two years later Hartmann³ corroborated Sudeck's findings and remarked that in the perineal excision of the rectum with transplantation of viable bowel to the perineum, the superior hemorrhoidal artery must be ligated high on the common trunk above the last anastomotic loop. He further commented that this ligation could only be performed through an abdominal approach. Sunderland⁹ pointed out that in the illustration used by Hartmann, the lowest sigmoidal artery was not shown and that the point of ligation indicated by Hartmann was quite high on the inferior mesenteric artery. Archibald,¹ in 1908 demonstrated by animal experiments and postmortem dissections the significance of the marginal artery and proved to his satisfaction that the rectum and pelvic colon could be resected and viable iliac colon successfully brought down to the anus. Rubesch,⁵ in 1910, also using an injection method, found that the lowest sigmoidal artery, the sigmoid ima, may arise from the superior hemorrhoidal after it has bifurcated. Thus, the critical point may vary from 13 to 20 cm from the anus. Drummond,² in 1914, studied roentgenologically the injected inferior mesenteric artery in 20 specimens. In 40 per cent of the cases the last sigmoidal artery and its proximal anastomosis were insignificant and in another 20 per cent of the cases the artery was not even present.

Steward and Rankin,⁷ on the basis of an extensive study of 100 injected specimens, described a gap in the bowel between the termination of the marginal artery and the bifurcation of the superior hemorrhoidal artery. This segment was found to be supplied by one to five small arteries which arose from the superior hemorrhoidal artery and which varied in size and number with other anatomic variations in this region, that is, a high, low or absent last sigmoidal artery or a low bifurcation of the superior hemorrhoidal artery.

Sunderland⁹ dissected the arteries to the distal colon in 20 specimens and studied the injected arteries of five additional specimens roentgenologically. The fact that he used dissection as well as the injection method, whose results may be open to question (Rankin and Graham⁴), may account for the variation between his studies and those of other workers.

The number of sigmoidal arteries was found by Sunderland to vary from one to seven in number. They did not form any definite or constant pattern. Our operative experience has been similar. The configuration of the inferior mesenteric artery and its branches must be determined in each case by transillumination of the mesentery. Only in this way can the proper point for ligation be established, consistently. Thus, on the basis of studies of cases at operation, we have confirmed the recommendation of both Sudeck⁸ and Hartmann³ that it is wise in each patient to observe the arterial pattern of the inferior mesenteric artery and its branches.

When present, the lowest sigmoidal artery was found by Sunderland⁹ to descend vertically to the rectosigmoid and supply the upper portion of the rectum which is also supplied by the superior hemorrhoidal artery. This is at variance with the findings of Steward and Rankin⁷ which have been stated previously. Sunderland found Drummond's² statements concerning the relationship between the superior hemorrhoidal artery and the lowest sigmoidal artery less than explicit. The former demonstrated that the two vessels overlap in their supply of the upper rectum but in only five of 25 cases was there any anastomosis.

In the technic of abdominoperineal sigmoidectomy with preservation of the sphincters, the last sigmoidal artery may be disregarded whether one accepts the views of Steward and Rankin or Sunderland. The superior hemorrhoidal artery cannot be ligated below the origin of this vessel and allow sufficient mobility of the bowel to permit its being brought down to the anus without tension. As a corollary, it is impossible in performing this operation to clamp the superior hemorrhoidal artery at the critical point of Sudeck.

Sunderland⁹ discovered that there was a well-marked anastomosis with a continuous vascular arcade (marginal artery of Drummond) between all sigmoidal arteries. He remarked, however, that his findings disagreed with those of Drummond² who found the lowest sigmoidal artery and its proximal anastomosis to be insignificant in 40 per cent of the cases and the artery to be absent in another 20 per cent of the cases. In view of this discrepancy, Sunderland believed it prudent to ligate the inferior mesenteric artery at a level higher than that between the lowest two sigmoidal arteries, there has been general agreement regarding the competency of the arterial anastomosis above this level. In our operative experience we have been able to segregate those cases in which ligation may be made safely between the lowest two sigmoidal arteries from those in which ligation must be performed higher than the second lowest sigmoidal artery to assure viability by the simple precautions previously described. Chief among these measures has been transillumination of the mesentery before and after ligation of the inferior mesenteric artery.

Sudeck's⁸ critical point has been shown to vary with the individual pattern of the arteries to the lower sigmoid. It varies with the type of surgical procedure to be performed. In the Miles-type of operation viable bowel must be brought out as an abdominal colostomy. As shown by Singleton,⁶ this should present no difficulty when the inferior mesenteric artery is ligated above the lowest sigmoidal branch. On the bases of the anatomic studies which have been described, if there is doubt regarding the adequacy of the blood supply to the colostomy loop, ligation need only be done above the second sigmoidal artery to insure sufficient blood flow. Drummond² stated that where a permanent colostomy is done, the inferior mesenteric artery may be ligated just below the origin of the left colic artery.

In an end-to-end anastomosis following resection of the sigmoid, viability of each end must be assured. It is in this operation that the critical point is most significant, indeed a hypothetical situation could arise in which the rad-

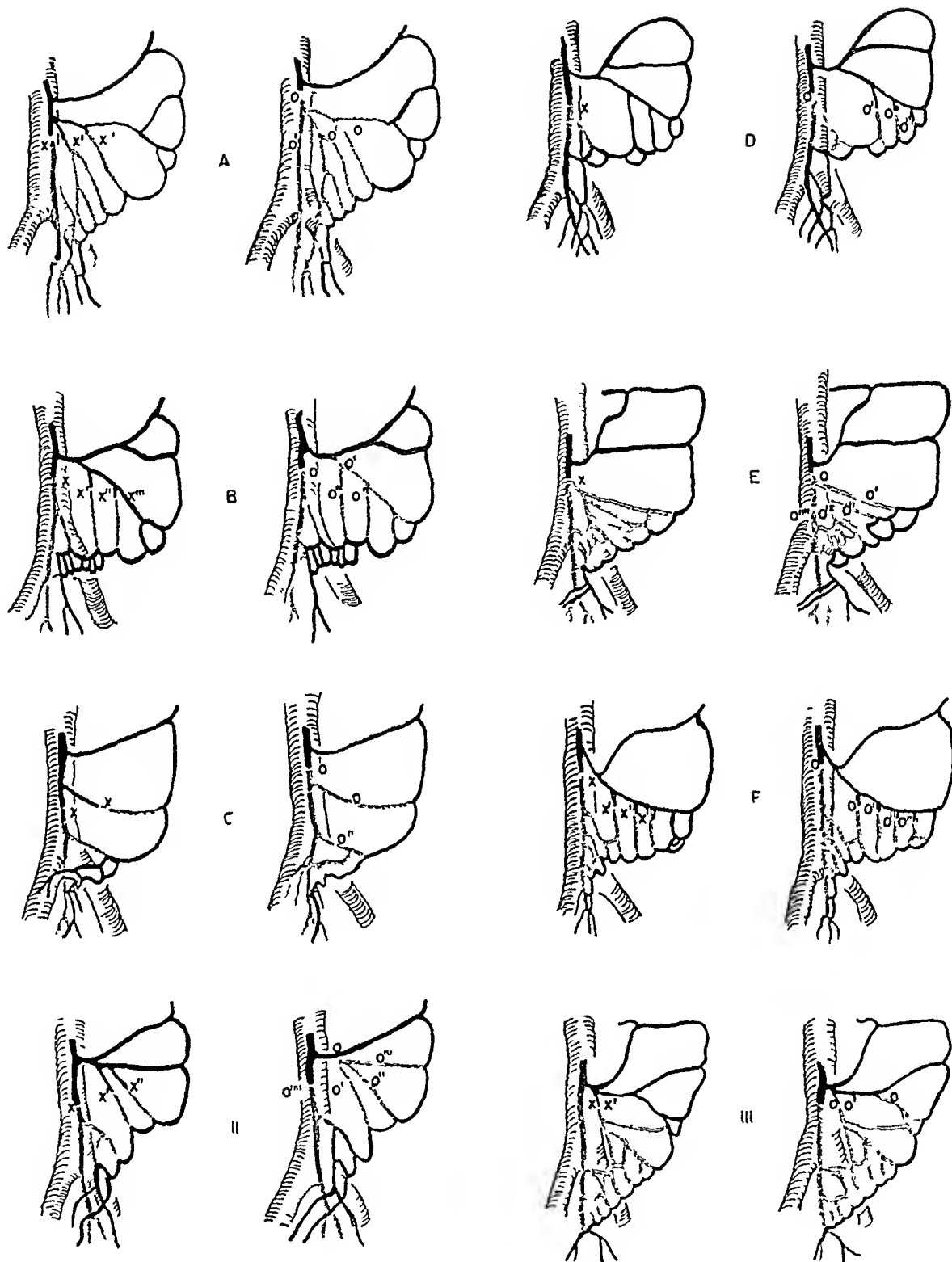


PLATE I—Drawings, adapted from Sunderland, of the aorta, the common iliac arteries, the inferior mesenteric artery, the left colic artery, the sigmoidal arteries and the superior hemorrhoidal artery in each of eight patients (A, B, C, D, E, F, II, III). The preferred and acceptable alternate points of ligation of the inferior mesenteric and sigmoidal arteries are indicated by X, X', X'', X''' and O, O', O'', O''' respectively. The points also outline that portion of the sigmoid mesocolon and lymph gland bearing tissue which will be removed during the perineal phase of the operation. The route of the preserved blood supply to that portion of the bowel which is to be transplanted to the perineum is denoted by red. The interrupted arterial pathways are indicated by blue (Bacon & Smith).

icalness of the resection might be compromised to attain viability of the bowel ends. A detailed discussion of the relationship of this operation to the arterial blood supply of the distal colon is beyond the scope of this paper. The reader is referred to Sunderland's discussion of this topic.

As has been shown, in performing abdominoperineal proctosigmoidectomy with preservation of the sphincter mechanism, the critical point of Sudeck need hardly be considered. Ligation of the inferior mesenteric artery must be performed above the lowest sigmoidal artery at least to permit the mobility of the colon necessary to bringing it to the anus. Furthermore, the inferior mesenteric artery may be deliberately ligated much more proximally in cases where more of the upward lymphatic pathway is to be removed or where one is not completely satisfied with the competency of the circulation to that portion of the bowel to be brought to the anus. In the average case we have agreed with Drummond that the most convenient place to ligate the inferior mesenteric artery is immediately below the first sigmoidal branch, which can be recognized by the large anastomotic branch it forms with the left colic artery.

In selected cases of polyposis, ulcerative colitis, diverticulitis, and lymphopathia venereum, the rectum, sigmoid, descending colon, splenic flexure and a portion of the transverse colon have been excised. In these cases all branches of the inferior mesenteric artery have been ligated and the stump of transverse colon has been brought down to the perineum. Viability has been maintained by the middle colic artery. These patients are the basis of a separate report.

The blood supply to the rectum beyond the bifurcation of the superior hemorrhoidal artery presented no controversial points and its discussion has been omitted. The blood flow to the preserved sphincter muscle and anal skin is abundant by way of the internal pudendal arteries.

SUMMARY

A review of the anatomic studies of the arterial supply of the distal colon and a correlation of these studies with the technic of abdominoperineal proctosigmoidectomy without colostomy and with preservation of the sphincter mechanism have been presented. The operative measures which, in our hands, have insured the transplantation of viable bowel to the perineum have been presented.

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SURGICAL TREATMENT OF CARDIOSPASM

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THOUGH MANY PATIENTS with cardiospasm receive symptomatic improvement for varied periods of time following instrumental dilatation of the esophagogastric junction, the benefit obtained is rarely complete or permanent. No evidence of reduction in the size of the esophagus following dilatation has ever been presented. In some patients the tortuosity of the esophagus prevents instrumentation and in others no significant improvement results from this therapy.

The operative procedures designed for relief of this condition have been as varied as the theories presented as to its pathogenesis and have been directed at the dilated esophagus, the cardia, its nerve supply, and the diaphragm. Though isolated reports of successful results from each of these methods have been published, the majority of these technics have not been universally satisfactory. Of all operative procedures, those technics directed at the esophagogastric junction in which the size of this stoma is enlarged, appear to have given the best results. Even after these operations it has usually been stated^{1, 2, 3} that the functional results were better than the roentgenologic evidence of improvement. Considerable discussion has also been presented regarding the relative merits of the transabdominal and the transpleural approaches. Most opinions have favored the transabdominal approach, in that this was felt to be associated with less risk.

The purpose of this paper is the presentation of the surgical technic employed and the postoperative results in 17 patients having transpleural cardioplasties who had not been significantly improved by instrumental dilatation. This group of patients is of interest not only because of the symptomatic improvement but also because of the marked reduction in the size of the esophagus postoperatively (Figs 1, 2 and 3).

All of the cardioplasties were performed through a transpleural approach, for it was felt that this allowed better exposure of the esophagogastric junction, better mobilization of the lower esophagus and cardia of the stomach and, in turn, the construction of a larger aperture than would be possible through an abdominal approach. The new stoma was made large enough to allow for its reduction in size as the caliber of the esophagus decreased. The size of the stoma determines the ease with which the esophagus empties itself and the likelihood of its reduction in caliber.

The first three cardioplasties were performed in a manner similar to a Finney pyloroplasty technic, the others in a manner similar to a Heineke-Mikulicz pyloroplasty technic. The latter type was found to be the easier and

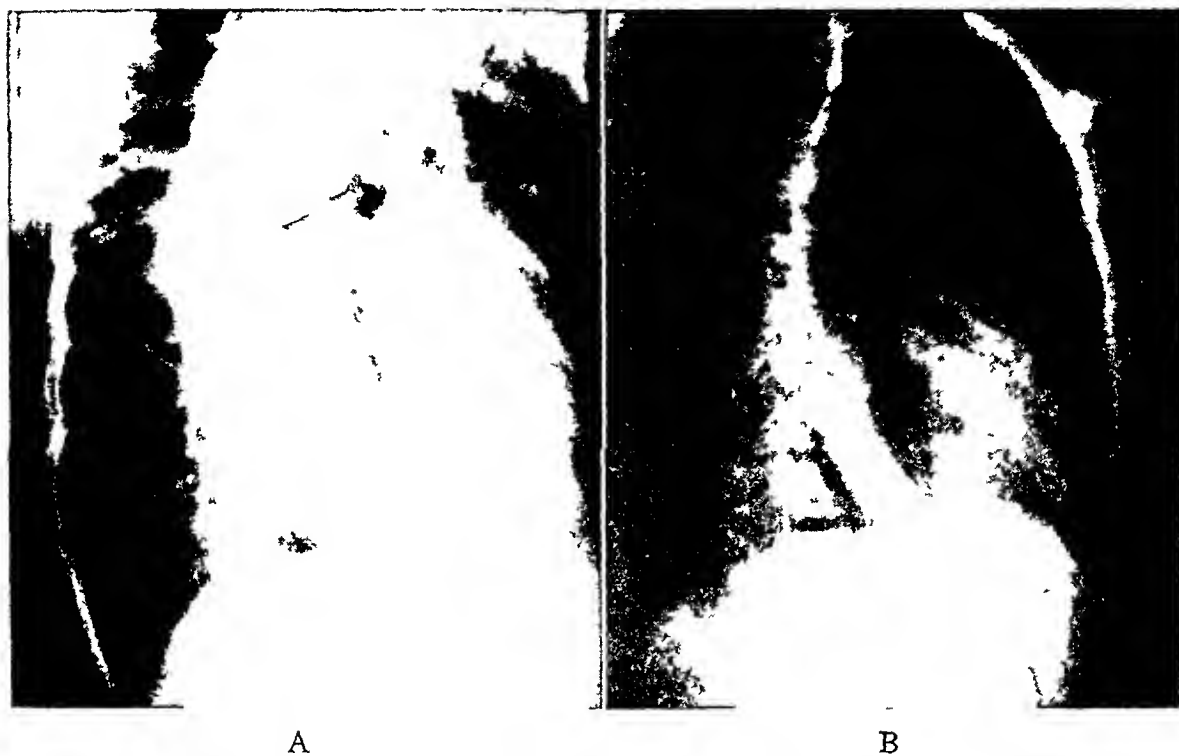


FIG 1—Esophagograms before (A) and six weeks after cardioplasty (B)

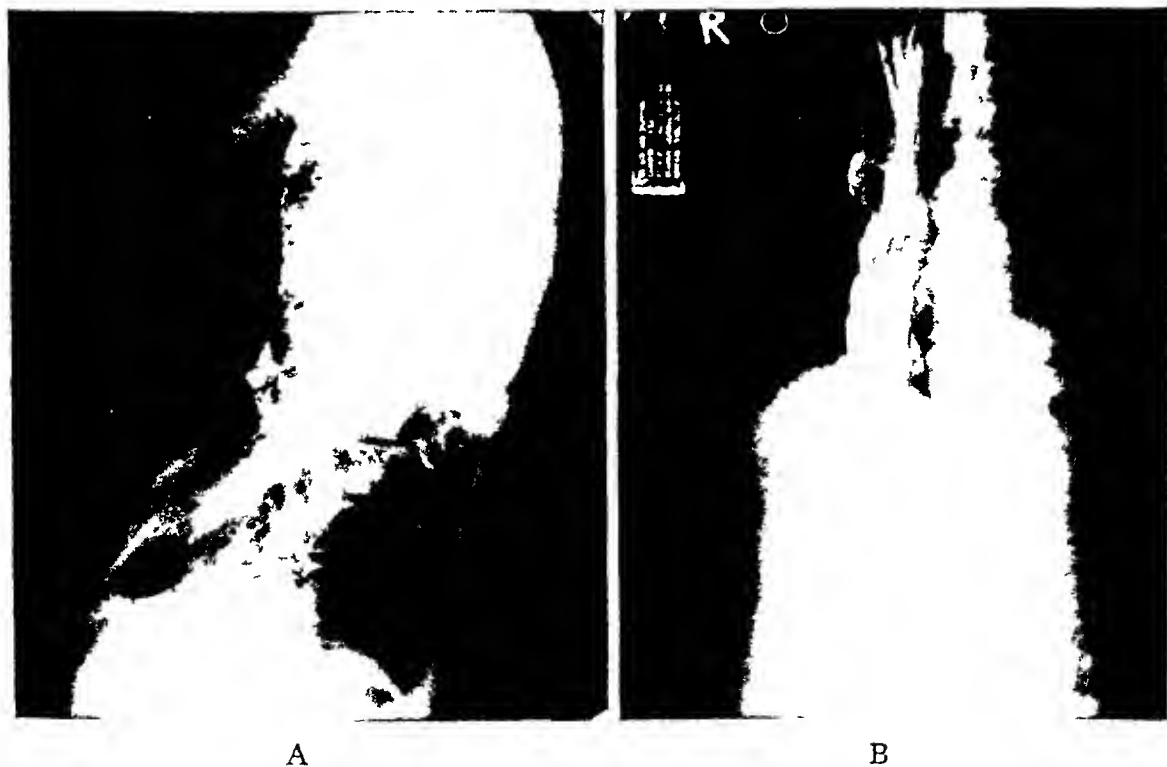


FIG 2—Esophagograms before (A) and six weeks after cardioplasty (B)

more satisfactory procedure. This technic was first employed by Wendel,⁴ in 1910. As illustrated in Figure 4, the lower esophagus is mobilized and carefully inspected. The diaphragm about the diaphragmatic hiatus is incised



FIG 3—Esophagograms before (A) and two months after cardioplasty (B)

radially for three to four centimeters to allow examination of the diaphragmatico-esophageal ligament and its attachment to the esophagus and esophagogastric junction.

Care is exercised to excise any limiting bands in this ligament. This ligament appeared responsible for the esophageal obstruction in five patients.⁵ In the first patient upon whom this observation was made, the diaphragm was incised lateral to the hiatus and the lower esophagus retracted into the abdomen. The diaphragmatico-esophageal ligament appeared markedly hyper-

FIG 4—(A) The lower esophagus and esophagogastric junction have been mobilized. The diaphragmatic hiatus has been enlarged and the diaphragm inverted exposing the diaphragmatico-esophageal ligament of its under surface as it is inserted into the esophagogastric junction.

(B) The diaphragmatico-esophageal ligament has been separated and the peritoneal reflection incised. The cardia of the stomach has been retracted into the thoracic cavity. The esophageal and cardial lumina have been occluded by umbilical tape. Two constrictions in the lower esophagus and esophagogastric junction at the sites of insertion of the diaphragmatico-esophageal ligament are apparent.

(C) A large longitudinal incision has been made through the esophagogastric junction and extended in both directions. A section of this junction was taken for microscopic study.

(D) The above incision is closed transversely by a mucosal layer of continuous catgut suture and an outer layer of interrupted black silk sutures.

(E) The new stoma has been replaced into the abdomen and a new diaphragmatic hiatus made by suturing the diaphragm about the esophagus at a higher level.

B



E



D



C



A



trophied and taut as it was inserted into the lower esophagus. All of the visible portion of this ligament was incised at its insertion about the esophagogastric junction and lower esophagus. A Finney-type cardioplasty was then performed. Postoperatively, he still noted dysphagia and esophagograms again demonstrated obstruction at this site. Consequently, an abdominal exploration was done ten days postoperatively. The new stoma appeared widely patent and no abnormality could be found. An incision was then made in the anterior surface of the stomach and a finger was inserted into the esophagus where a button-like stenosis was encountered. This was retracted into the abdomen and found to be caused by a constricting band in the uppermost portion of the diaphragmatico-esophageal ligament that had not been severed at the first operation. The esophageal occlusion was immediately relieved as soon as this was incised. In one other patient, the anterior portion of this membrane was band-like in character and appeared to cause constriction, this was completely cut and marked improvement was noted postoperatively. The esophagus in this patient, however, did not decrease in caliber to the same extent as that noted in other patients upon whom cardioplasties were also performed. In seven other patients the diaphragmatico-esophageal ligament appeared normal but considerable periesophageal fibrous bands were in close contact with this ligament and adherent to the longitudinal musculature of the esophagus. It is now felt that this site can be best inspected by enlarging the diaphragmatic hiatus and retracting the cardia of the stomach into the thorax.

The peritoneum is incised and the cardia mobilized and retracted into the thorax. The esophageal and gastric lumina are occluded by umbilical tape to prevent spillage. A longitudinal incision is made through the esophagogastric junction and extended in both directions for approximately four inches. A section is frequently taken at this site for microscopic examination. This opening is closed transversely by an inner layer of running catgut suture followed by an outer layer of interrupted black silk suture. Approximately 100,000 units of penicillin are injected about the stoma. The stomach and new stoma are replaced into the abdomen and a new hiatus made by suturing the diaphragm at a higher level upon the esophagus. This also aids in straightening the esophagus. The chest is closed without drainage. The only postoperative complication to date has been a transient collection of serum requiring one to two pleural aspirations in four patients. Hourly feedings of milk are provided as soon as the patient awakens from the anesthesia but an inlying Wangenstein suction is employed and clamped intermittently for three days. The usual postoperative gastric diet is then provided. These patients have been able to note the sensation of food and fluids going immediately into the stomach upon swallowing, a sensation that they had not experienced for many years.

SUMMARY

The surgical technic employed and the operative results obtained in 17 patients having transpleural cardioplasties who had not been significantly

improved previously by instrumental dilatation is presented. In each patient there was a marked reduction in the size of the esophagus postoperatively.

All of the patients were convinced of the greater relief accorded by operation as compared to instrumentation. It can be argued from this that many patients with cardiospasm may exist for years with partial benefit from instrumentation who do not realize the more complete and permanent benefit that might be derived from operation.

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SPONTANEOUS RUPTURE OF THE MALARIAL SPLEEN

CASE REPORT AND ANALYSIS OF 64 REPORTED CASES

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SPONTANEOUS RUPTURE of the malarial spleen is a rare but dramatic complication demanding prompt recognition and surgical treatment. With the large numbers of cases of malaria in military service, traumatic and spontaneous rupture of these enlarged and friable spleens has been reported ten times in the past five years. In many instances, clinical malaria occurs only after cessation of atabrine and return to civil life. Best and Schmid¹ recently reported three cases and collected 35 (including nine inoculated syphilitics) in the literature from 1920 to 1945. Kaplan, *et al.*²⁰ reported a case occurring in an inoculated paretic and listed 31 similar cases. In our review of the American and foreign literature since 1917 we have found 64 cases of spontaneous splenic rupture in inoculation and naturally-acquired malaria.¹⁻⁵³ Seventy-two cases prior to 1917 were reviewed by Leighton.⁷⁴

Because large numbers of cases of malaria will relapse in communities where the disease is unfamiliar, and because only early diagnosis and prompt treatment will lower the present high mortality, we believe a report of our case and a review of the literature is timely. Also, there are important clinical differences between the syndrome occurring during malarial treatment of syphilitics and in naturally-acquired malaria which are not generally appreciated.

Case Report—No. 19505. This 37-year-old veteran was brought by ambulance, January 2, 1946. Because he was semiconscious, history, at first, was obtained chiefly from his wife.

CC. Weakness, collapse, and epigastric pain of several hours duration.

PI. The patient had served 31 months in the South Pacific, taking atabrine 0.1-0.2 Gm. daily. Twenty days before admission he arrived in the continental limits of the United States and stopped atabrine.

Five days before admission he developed fever, shaking chills, generalized aches and pains, severe headaches, and his head and nose felt "all stopped up." Four days before admission he became nauseated, and he vomited four to five times daily thereafter, and vomitus had occasional flecks of red blood. He had much epigastric soreness. There were no blows, falls or even minimal trauma, recent or remote. Because of fever and malaise he remained in bed after the first few days.

Several hours before admission he vomited and shortly thereafter, while in bed, experienced a severe, sudden epigastric pain which caused him to cry out, draw up his knees and faint. When he quickly recovered consciousness, he remained weak, complained bitterly of pain in the upper abdomen. No pain in the shoulder or elsewhere.

FH PH and system review Noncontributory

PE A well-developed, well-nourished young man in collapse, pale, sighing, restless and apathetic

T 104° F by rectum, pulse 110 and barely perceptible

BP 70/50 R 24

Once during examination he became unconscious and was resuscitated with oxygen inhalations, plasma infusion and intravenous stimulants. The significant positive and negative findings were as follows. The abdomen had slight rigidity everywhere, but there was marked tenderness and spasm in the left upper quadrant near the costal margin. The spleen could not be felt due to spasm. There was no audible peristalsis. No distention.

The remainder of the physical examination was negative, except the marked atabrine pigmentation of skin, sparing the sclerae. Extremities were cool. Neck supple, brisk neurologic examination negative. Heart and lungs normal.

While awaiting reports from the laboratory and blood for transfusion, the treatment given was morphine sulphate 10 mg subcutaneously, plasma 500 cc intravenously. When *P vivax* was reported on smear, quinine dihydrochloride 0.25 Gm intravenously, diluted in 250 cc normal saline was started but soon replaced with plasma and atabrine 0.4 Gm substituted intramuscularly.

Laboratory Data—White blood count 5,000, with 44 per cent segmented and 32 per cent band-like neutrophils, 20 per cent lymphs, hemoglobin 13 Gm per cent. Numerous *P vivax* were seen on thick and thin smear. Some parasitized cells were slightly enlarged. Thick drop showed many small and large trophozoites, rare presegmenting schizonts, but no gametocytes. Urinalysis showed 10 mg per cent albumin, but was otherwise negative. No hemoglobinuria. Chemical test for urinary atabrine was negative.

Diagnosis—While blood for transfusion was awaited the generalized abdominal spasm became more marked. These signs of spreading peritoneal irritation following sudden shock, with severe pain spasm and tenderness in the splenic region of a man with malaria, caused the diagnosis of spontaneous rupture of the spleen. Five hundred cubic centimeters citrated blood was given intravenously and the blood pressure rose to 105/60, so operation was begun.

Operation—(Dr O. C. Williams)* Eight hours after onset, under nitrous oxide-oxygen-ether anesthesia, the abdomen was opened through a muscle-splitting incision of the left upper rectus. The peritoneal cavity was entered, and 600 cc liquid blood removed by suction. A large clot, the equivalent of another 500 cc of blood, lay over the spleen. The enlarged and ruptured spleen was readily removed.

Postoperative Course At the end of the operation the blood pressure fell to 80/60, and the pulse rose to 160. Two 500 cc transfusions were given simultaneously with good response and followed by a third. Two hours postoperatively the blood pressure was stabilized at 140/100. The usual postoperative management was followed, with addition of atabrine 0.2 Gm i.m. q four hours for six doses, and thereafter 0.1 Gm was given daily for another few weeks. Several malaria smears were negative, and the fever gradually subsided, but the temperature was not normal until the 30th day. Hemoglobin rose to normal, repeated smears and white blood counts were unremarkable. The patient was discharged well on the 30th hospital day.

Pathology Report—Gross The spleen was enlarged (Fig 1), measuring 15 x 10 x 5 cm, and weighing 380 Gm. On the convex surface the capsule had been stripped away over a large area, uncovering the underlying irregular, raw, splenic tissue. In the central portion of this exposed surface there was an irregular, funnel-shaped rent in the pulp, measuring 8 mm in the diameter and 2 to 3 mm in depth. Submitted with the specimen was a large blood clot representing approximately 400 or 500 cc of blood. The remaining intact capsule was tense. On section, the splenic tissue was found to be moderately soft, dark red in color, bulging above the cut surface. A small amount of moist, soft, red

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tissue could be scraped from the surface. The malpighian follicles were not grossly apparent.

Microscopic Sections were taken from the vicinity of the tear on the convex surface as well as from other areas in which the capsule was intact. The tissues were stained with the hematoxylin-eosin, van Gieson, Romanowsky, Gimsa, iron pigment, and reticulum stains. All sections showed essentially similar changes, including those from the site of rupture as well as those removed from other regions. Surrounding the rupture the capsule was stripped away, leaving only a thin single layer of connective tissue as a covering. Elsewhere, the capsule was covered by a fine, fibrinous deposit.



FIG 1—Ruptured spleen in acute malaria, spleen enlarged, soft, arrow points to site of rupture

The follicles were enlarged but inconspicuous, merging diffusely with the red pulp, due to the general cellularity of the entire organ. The germinal centers were enlarged and pale. Their constituent cells were loosely arranged, separated by a pinkish-staining, amorphous, ground substance resembling coagulated edema fluid. The cells were varied—some being enlarged, pale-staining reticulum cells—others, small lymphocytes, were darkly stained, apparently undergoing degenerative changes. There were also nuclear fragments. Mitotic figures were occasionally found. The pale central zone was sharply demarcated against the peripherally-located portion of the follicle. The latter was large and contained the usual lymphocytic cells, although mitoses were frequently seen.

The *red pulp* was extremely cellular, the cells being of varying types. By far, the most prevalent were the large reticulum cells found within the widened splenic cord. These showed storage of two types of pigment: fine granules taking the iron stain (blood pigment), and coarse dark brown grains (malarial pigment) which had no affinity for the iron stain. The endothelial cells lining the sinusoids were numerous and hyperplastic, projecting into the lumen or desquamating completely into it. Several of these cells contained pigment similar to that found in the reticulum cells. Plasmodia could not be identified within any of the nucleated cells.

RUPTURE OF THE MALARIAL SPLEEN

The sinusoids (Fig 2), for the most part, contained few red cells but were completely engorged with white cells. These appeared to be mostly desquamated endothelial cells. However, they also contained numerous macrophages, often large and multinucleated, which contained iron pigment as well as large, coarse, granules, similar to that found in the reticulum cells. Occasionally, polymorphonuclear cells were also present.

FIG 2

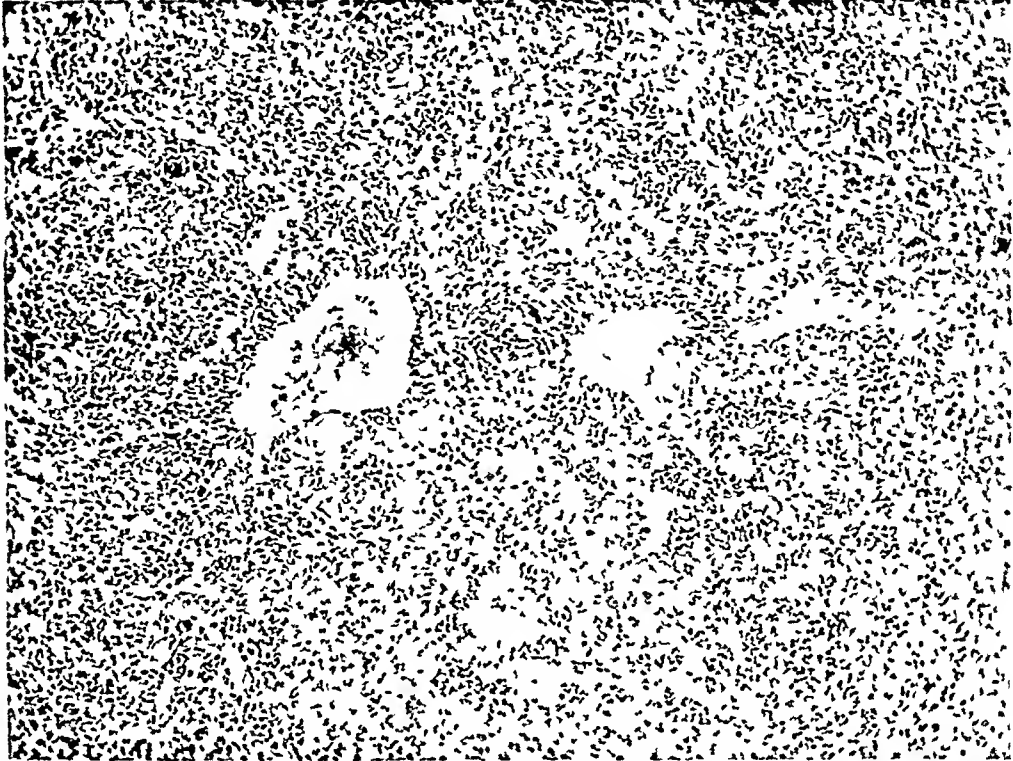


FIG 3

FIG 2—*Sinusoids*: Some are dilated, others are engorged with macrophages.
FIG 3—*Veins*: Dilated, filled with macrophages. On the right a thrombus is in the process of formation. Subendothelial myelopoiesis.

Conspicuous was the enormous dilatation of some of the sinusoids. Some contained the aforementioned cells, many, however, were engorged with red cells. These cells lay close against the wall and were continuous with the cord cells. Occasionally, the entire mass was converted into a thrombus. The sinusoidal wall here was indistinct or lacking.

Veins. Many were dilated (Fig 3), and filled with cells similar to that found in the dilated sinusoids. Thrombus formation was also apparent. Immediately under the endothelial layer the tissue was loose and a thin layer was formed containing macrophages and monocytes, with some phagocytosis of pigment. Essentially, the cells were similar to that found in the splenic cord and in the sinusoids.



FIG 4—Splenic infarction, subcapsular. Thrombosis, infarction and necrosis

In many portions of the spleen, but particularly under the capsule, a peculiar degenerative change was noted (Fig 4). Associated with a dilated thrombosed vein or sinusoid, there was complete disruption of the architecture of the sinusoids and the cord. The tissue was an admixture of all of these cells, including red cells, hemolyzed blood, degenerating white cells and a pinkish-staining amorphous fibrinoid substance, all merging into a poorly-defined conglomerate. Numerous areas of this type were found under the capsule.

Scrapings from the fresh organ stained with Wright and Giemsa stains showed rare mature trophozoites of *P. vivax* within the red cells. No parasites were found within any of the white cells or macrophages.

The 64 cases in the literature since 1917 are listed in the bibliography.^{1, 33} There were no case reports, merely mention of their occurrence in many instances.⁴⁰⁻⁴⁹ Some articles were not available to us.^{19, 22 and 50-53} Many case reports were incomplete, some had no pathologic or microscopic examinations performed. However, we have read and tabulated such data as was presented in cases listed in bibliography.^{1-18 and 23-29} Fairly detailed reports were available in some instances, and are the sources of the data in the section on the

clinical features in spontaneous rupture One case was reported separately by two authors^{24, 25} Several authors recorded two cases^{18, 39, 28, 40, 42, 47, 43} Two men observed three cases^{1, 46}

INCIDENCE

The occurrence of spontaneous rupture in allegedly normal spleens is rare A few instances have been reported in each of 16 different diseases accompanied by splenomegaly By far, the most common cause of spontaneous rupture is malaria Since Leighton's review, 25 cases of spontaneous rupture have been reported in naturally-acquired malaria^{1 22} Thirty-nine cases have occurred since malaria was first induced for treatment²³⁻⁵³

TABLE I
INCIDENCE OF SPONTANEOUS RUPTURE OF
SPLEEN IN INOCULATION MALARIA

De Cary	2 274	
De Asis	2 101	
Wile	1 1026	
Moore	2 1600	
Fong	2 1012	
Driver, <i>et al</i> ⁷⁷	0 2479 (review)	
Cantacuzene	1 528	
Dattner	0 5000	
Total reported inoculation cases in literature		39
Total reported cases naturally-acquired malaria (1920-1946)		25

The incidence of spontaneous splenic rupture in induced malaria is shown in Table I, and does not include unreported or unrecognized instances This is considerably higher than the incidence in naturally-acquired malaria, probably because of the preexisting splenic pathology,^{55, 56} the older age, and the longer duration of the malaria without specific treatment

With only two exceptions,^{51, 24} all inoculations were for treatment of central nervous system syphilis Spontaneous rupture has occurred as early as two days after the onset of symptoms, and a third of our present series occurred later than 15 days However, in a series of 5,000 cases which were interrupted after eight chills, no cases of rupture of the spleen occurred⁵⁷

Traumatic rupture of the spleen is very frequent in malarious climes Because of great enlargement, exposed position, congestion and friability, malarial spleens are readily ruptured by minimal trauma, and in one region $\frac{1}{30}$ th of all deaths are allegedly caused in this way⁵⁸ In Berger's review⁵⁹ (1902) of 123 cases of traumatic rupture of the spleen, 93 had malaria

Spontaneous rupture of the spleen in naturally-acquired malaria is rare It is estimated to occur once per 100,000 infections by Manson-Bahr In the Canal Zone, it occurred three times in 30,000 hospital admissions,⁶⁰ and in three of 100 malarial deaths⁶¹ It causes 4.45 per cent of all malarial deaths in one section of India (Massari). Although it is a rare complication, prompt diagnosis and treatment will save some persons who would otherwise certainly die

SPECIES AND STAGE OF MALARIA

Spontaneous rupture has been reported with all species except *P. malariae*. The great majority are *P. vivax*, which was found pre- or postoperatively in 16 of 19 cases in which species was stated. It may be assumed that the great majority of inoculations were *P. vivax*, even when not specifically stated. Two cases were *P. falciparum*, and one, *P. ovale*. Multiple ring forms were not observed in the *P. vivax* from our case. The species or strain made no difference in the clinical picture of the reported cases.

Superinfection, or degree of parasitemia, apparently, was of little consequence, since four cases occurred during afebrile or chronic stages of the disease. In no case of active malaria was it remarked that the paroxysms, or other features, were more severe than usual. However, some cases had much vomiting, diarrhea or delirium.

PATHOLOGY OF SPLENIC RUPTURE IN ACUTE MALARIA

The pathology of the spleen in acute malaria in humans is well-reviewed by Toliaferro and Mulligan,⁶³ and by Ash and Spitz,⁶² and our specimen revealed the changes reported. The alterations of sinusoids and veins were very noticeable in our case, however. Otherwise, the phagocytic, degenerative and hyperplastic changes were those well-recognized in acute malaria.

The sinusoids and veins are dilated and filled with macrophages and blood cells. The trabecular veins form a layer of reticulum cells under the endothelium and, less commonly, under the adventitial layer, similar to that found in the splenic cord. Within the pool caused by the dilated veins and sinusoids, the macrophages, red cells and even polymorphonuclear cells lie in a pinkish-staining fibrinoid material resembling a thrombus. These aggregates lie so closely against the wall that it is often difficult to determine whether they project from the cords. Rigdon⁶⁴ believes that the hyperplastic splenic pulp actually protrudes into the sinusoids. Thrombi formed in the arterioles, capillaries, veins and sinusoids are associated with hemorrhage, necrosis and infarction. Subcapsular splenic hemorrhages in acute malaria are frequent.

PATHOLOGIC FINDINGS IN REPORTED CASES OF SPONTANEOUS RUPTURE

Of the 58 cases of spontaneous rupture of the spleen in malaria, which have been available to us, only 29 include any sort of pathologic description. The pathologic findings in both types are similar and conform to the best literature^{62, 63}. There were no significant differences related to the species.

Grossly, the spleen was enlarged in all but one case, but because average weights were 450–500 Gm, many would not have been palpable. Hemoperitoneum had occurred in all but one case,³⁶ and was due to rupture of the splenic capsule with only two exceptions. In one instance, an accessory spleen had ruptured,² and in another case a hole was found in a tiny hilar vein.¹ In every instance, the slight to moderate enlargement and the color and consistency were typical of acute malaria.

Despite older statements, rupture of the capsule had no predilection for

convex or posterior surface. Presence of adhesions to the diaphragm were noted in four cases, and by limiting equal expansion of the spleen this may have contributed to the rupture. In 25 cases the number of tears was noted. Three spleens had burst into fragments. Nine others had multiple tears. That the initial step in rupture of the capsule is frequently formation of subcapsular hematomas is indicated by their occurrence in five cases. In three cases, rupture of the subcapsular hematoma occurred during surgical manipulation^{18, 24, 1}

More or less complete microscopic descriptions are reported in 16 cases. These follow the general description of the spleen in acute malaria, as indicated above. Nine cases described vascular changes, in two, this was apparent grossly as anemic infarcts. Microscopically, all nine showed foci of interstitial hemorrhage and occasionally thromboses and infarcts, similar to our case, or as described by Rigdon⁶⁴. We believe these interstitial subcapsular hemorrhages and infarctions result from endothelial swelling and subintimal infiltrations in small veins.

PATHOGENESIS AND MECHANISM OF RUPTURE

The mechanism of rupture of the normal and enlarged spleen may be threefold: (1) local lesions as points of weakness, (2) increase of tension due to hyperplasia and engorgement, and (3) compression by the abdominal musculature.

Because the exact site of initial subcapsular bleeding or capsular rupture cannot usually be identified and may be destroyed in the process of rupture, the etiologic rôle of local lesions must be inferred from the presence of similar lesions elsewhere in the spleen.

The spleen, even in normal persons, is frequently the site of pathologic changes that predispose it to rupture. Arteriosclerotic alterations of vessels may result in "splenic apoplexy" (Ask-Upmark)⁷³. Adhesions and thickenings of the capsule may prevent equal expansion and accommodation to increased tension. One case in this series had calcareous deposits in a large part of the capsule which had ruptured at another weaker and expanding site³⁶. Contusions may cause subcapsular hematomas, later organized into blood cysts. It is perhaps in this way that trauma may, after a free interval of days or weeks, be an important cause of allegedly spontaneous ruptures. In severe *P. vivax* as well as in *P. falciparum* malaria the spleen may have infarctions, focal necroses and multiple interstitial and subcapsular hemorrhages, such as occurred in our case, and in nine of the cases with adequate microscopic examinations. In common with Rigdon's hypothesis, our sections illustrate how reticular and endothelial hyperplasia obstructs venules and sinuses and causes the interstitial and subcapsular hemorrhages. Subcapsular bleeding continues, strips away the capsule over a larger area, and results in further bleeding and distention of the capsule, which ultimately bursts.

The underlying pathology of the paretic spleen may partially explain the higher incidence of splenic rupture in that group of malaria cases. Changes in the fibrous tissue cause loss of elasticity of many paretic spleens^{55, 56}.

Lubarsch believes paretics' blood vessels are more friable and, therefore, splenic rupture is more likely.⁷⁴ The average duration of active malaria prior to rupture was longer for the paretics than for the normals with malaria, and this might indicate greater resistance or explain the greater incidence of rupture. However, the group is too small to be statistically significant, and the protected life of the inoculation cases would weight the figures in the opposite direction (Table II).

TABLE II

	CNS Syphilis with Malaria	Normals with Malaria
Cases Analyzed	18	20
Average age	40	29
Number of males	15	18
Number of females	2	2
Number of unstated sex	1	0
Days duration of acute malaria		
Not stated	1 (12 chills)	3
Not acute	1	3
Less than 7 days	6	10
7-14 days inclusive	2	3
Over 14 days	8	1
Duration of rupture in fatal cases without operation		
Total	17 studied	4
Less than 3 hours	7	4
3-24 hours	3	All others operated upon
24-48 hours	4	
Over 48 hours	1	
Intermediate	2	

The general increase of tension within the capsule caused by rapid enlargement is probably the most constant etiologic factor in malaria, as well as the other splenic enlargements that rupture. In chronic malaria gradual enlargement may not increase the tension and splenic puncture has been performed in such cases with no immediate ill results.⁷⁵ Splenic puncture in rapid enlargements may be disastrous, as we have observed in a case of kala-azar, who died following this procedure.⁷⁶ Many of the spleens in this series had multiple deep rents or were fractured completely, suggesting almost an "explosion" of the spleen. Malaria is *par excellence* the cause of rapid splenic hyperplasia and, therefore, the most frequent cause of spontaneous rupture. Ask-Upmark⁷³ believes reflex spasm of the splenic vein may cause acute congestion and play a rôle in some nonmalarial cases of spontaneous rupture.

The influence of increased intra-abdominal pressure caused by muscular contraction seems significant in some cases. Allegedly normal spleens, as well as a malarial spleen in our present series, have ruptured during labor.⁸ Vomiting due to intestinal obstruction may have been an etiologic feature in one case.³⁹ Vomiting was a prominent feature of the illness prior to rupture in nine additional cases, including ours^{1, 3, 6, 11, 14, 33, 34}. Diarrhea occurred in one,²³ and in two, the onset occurred during defecation,^{1, 5} and in one case

while pushing a wheelbarrow¹³ Delirium and restlessness were noted in six cases, and all but one of these were paretic

The relative importance of each of these three factors is difficult to assay From evidence at hand, all three factors are seldom operative in any single case and the series is too small for any but the most general conclusions about pathogenesis

CLINICAL FEATURES OF SPONTANEOUS RUPTURE OF MALARIAL SPLEEN

The signs and symptoms recorded in 38 cases in fair detail have been tabulated and are the source of the following data Miscellaneous symptoms of associated acute or chronic malaria were overshadowed by the dramatic rupture of the spleen

The clinical features of the rupture were somewhat different in the inoculated cases than in the nonluetic persons The luetics were older by a decade, and all but one had acute malaria, and usually died less than two hours after onset Another contrasting feature is that over half of the syphilitics, including six who survived over two hours, and in whom fairly complete examinations were made, died with no complaints of pain at any time The profound shock was usually attributed to some cardiac complication It is probably because of the lack of pain and the scanty physical findings that the diagnosis was made in no instance, three were operated upon, with erroneous diagnoses,³⁴ with two survivals^{24, 53} The nonsyphilitics had severe abdominal pain in all but one instance

The signs and symptoms are chiefly those of (1) circulatory effects of acute blood loss, and (2) local abdominal effects of bleeding and rupture

The rapid deaths were all caused by severe blood loss and shock Our patient was pulseless, unconscious, and was resuscitated only by vigorous anti-shock therapy Lack of pain in many instances was probably due to the high pain-threshold caused by severe shock

Cases with fever have higher metabolic requirements, and acute blood loss in these cases causes earlier and more profound shock and anoxia, and even poorer heat dispersal and more rapid death Because a few temperatures were recorded in the most rapid deaths the occurrence of this vicious cycle cannot be proven in most cases The survival-time after rupture could not be correlated with the size of the spleen or with body temperature, or with the age of the person However, the duration of the malaria prior to rupture was greater in the more rapid deaths (Table III)

The onset of the rupture was sudden and clear, except in two cases,^{31, 39} and was heralded by pain or collapse Two of these had no pain at the onset, and the initial episode was probably formation of a large subcapsular hematoma^{27, 28, 32} The later onset of pain and second collapse was probably due to rupture of the capsule and hemoperitoneum

The pain of splenic rupture is somewhat variable (Table IV) It is usually severe, generalized, and worse in the left or upper abdomen and flank Two cases^{24, 32} had only lower abdominal pain This has been attributed to the irritation of blood gravitating to the lower abdomen (Manson-Bahr) Pain

TABLE III
SURVIVAL-TIME OF NONOPERATED CASES

	No of Cases	Average Age and Range	Avg Size of Spleen and Range	No of Days Malaria Symptomatic
Survival less than 3 hours				
Inoculation	7	43 years (30-50)	483 Gm (350-750)	12 (5-18)
Naturally-acquired	4	28 years (21-33)	417 Gm (350-453)	3 (2-4)
Survival over 3 hours				
Inoculation	8	42 years (26-64)	460 Gm (375-755)	8-4/7 (2-15)

in the left shoulder (Kehr's sign) referred *via* the phrenic nerve occurred in only six cases. Vomiting prior to, or after, rupture is not infrequent, and in two instances the vomitus contained small amounts of blood, probably due to gastritis associated with malarial infection or the treatment.

TABLE IV
PAIN IN SPLENIC RUPTURE

	Normals and Malaria	CNS Syphilis and Malaria
Degree of pain		
None	0	10
Mild	1	0
Severe	19	8
Site of pain		
Undescribed	3	0
Generalized	1	3
Left side	7	1
Epigastric	8	1
Lower abdomen	1	1
Left shoulder and abdomen	6	1
Precordium and left anterior chest	0	1

Except for the physical signs of acute blood loss, the chief findings were abdominal. Where time permitted and findings are recorded, the most common finding was generalized abdominal spasm, usually worse in epigastrium, and occasionally worse in, but rarely limited to, the left upper quadrant. Three cases, however, had no spasm whatsoever, although hemoperitoneum was found at operation. In only one case was the spasm described as "board-like." A few cases had slight abdominal distention, occurring late. The sign of Ballance, persistent left flank dullness in all positions and shifting dullness in the right flank, allegedly specific for rupture of the spleen, was reported in only one instance.

It is noteworthy that the spleen was palpable in only five cases, and it will be seen from the pathologic data that many of these ruptured spleens would not be readily palpable even without spasm in the left upper quadrant. Findings there, in addition to spasm and tenderness, described earlier, included dullness of the left flank in five cases.

LABORATORY DATA

Malaria films done preoperatively in eight cases were positive in all. White blood counts were done in only three cases. The usual leukocytosis of splenic rupture may be suppressed by the malaria, but in one case of active malaria the white blood count was 11,000. White count in our case was 5,000, with 75 per cent polys.

Hemoglobin preoperatively was low in five cases. Our case, however, had an hemoglobin content of 13 Gr per cent because hemodilution had not yet occurred.

Urinalysis in one case and in ours was essentially normal. Plain roentgenograms of the abdomen were made in two cases, and except for the finding of a large spleen in one case, no abnormalities were noted.

DIAGNOSIS

The diagnosis was made in only seven cases and suggested in two others. Perforated peptic ulcer was the preoperative diagnosis in four cases. Other diagnoses listed were "ruptured hollow viscus," "intra-abdominal abscess," "intra-abdominal hemorrhage," and "ruptured uterine tumor."

When active malaria is known to be present, the differential diagnosis includes chiefly the medical causes of malarial shock such as "cerebral malaria," and the other forms of overwhelming malarial infection. These cases are usually due to *P. falciparum*, while *P. vivax* malaria is the chief cause of ruptured spleens, and practically the only form encountered among the veterans. Our only other case of malarial shock was a young veteran admitted with *P. vivax* infestation and coma, convulsions, rectal temperature 108° F, and peripheral collapse.

During malaria treatment of central nervous system syphilis and during other active untreated infections, the occurrence of shock usually led to diagnosis of some intercurrent cardiovascular accident. It should suggest the possibility of rupture of the spleen, since localizing abdominal signs or symptoms may be lacking in the moribund patient. Electrocardiography may be the only differential point.

During latent, chronic or prepatent stages of malaria, splenic rupture is not so rapidly fatal, and localizing abdominal signs are more common. The differential diagnosis then includes the usual causes of acute abdominal emergencies, but chiefly perforated peptic ulcer. The shock due to hemorrhage and the shock of peritonitis may be clinically indistinguishable, if hemodilution has not yet occurred. However, the absence of an ulcer history, presence of a normal leukocyte count and plasmodia in the smear, a not exceedingly rigid abdomen, absence of free air under the diaphragm, and physical findings and symptoms pointing to the left upper quadrant are all helpful differential points and insure proper placement of the incision. Preparations for blood and plasma transfusion should be in progress during diagnostic studies.

Other common diseases such as left pyelonephritis, hydronephrosis, or perinephric abscess, or left lower lobe pulmonary disease caused no confusion in this series.

In the presence of known malaria and localizing findings in the left upper quadrant, without shock, the differential diagnosis includes perisplenitis, splenic infarction, and splenic abscess and volvulus of the spleen. Perisplenitis in malaria is probably the result of minor splenic infarctions, which are not uncommon. The clinical features, as manifested in a series of inoculated patients with central nervous syphilis, are discussed by Read, *et al*⁶⁸. Except for the lack of shock and the spontaneous recovery, the history and findings here were perfectly compatible with rupture of the spleen. We believe subcapsular hematomas are usually followed by rupture, and preparations should be made for emergency surgery.

Abscess of the spleen following malaria is an even rarer complication than splenic rupture.³⁶

Volvulus of the spleen has been reported in seven cases since 1930,^{8, 67, 68} and was once associated with rupture.⁶⁸ In all of these malaria was very chronic, the spleen weighed 1,550 to 7,000 Gm., and was frequently noted to be freely movable prior to the torsion. Except in hyperendemic regions, and in patients receiving poor treatment, this complication is practically unknown.

Other causes of atraumatic hemoperitoneum are listed by Reimann and Cowley.⁶⁹ They are less remediable, exceedingly rare, and have been diagnosed only at autopsy.

The difficulties of diagnosis of abdominal pain in latent and prepatent *P. vivax* malaria are well-discussed by Most and Hayman,⁷⁰ but their statement that "symptoms and signs of splenic rupture are so dramatic and the findings such that the diagnosis is usually made" is not borne out by this review. The presence of plasmodia in a blood smear does not rule out the need for surgery until the possibility of a ruptured spleen is excluded.

TREATMENT

The treatment of rupture of the spleen is always surgical because, although several alleged cases have recovered without operative treatment, this complication is almost always rapidly fatal.

Operative mortality in the eight cases between 1895 and 1920, before the advent of malarial therapy, is summarized in Table V. Comparison shows that the mortality has not been lowered in recent years, despite advances in technics of anesthesia, shock treatment, and splenectomy.

TABLE V

	Inoculation	Naturally Acquired 1920-1946	Naturally Acquired before 1920
Total cases	36	19	
Correct diagnosis	0	7	
Operations	3	15	8
Postoperative death	1	4	1
General mortality	94 5%	39%	Nonoperated almost 100%
Operative mortality	33%	26%	12 44%

Importance of early diagnosis is seen from Table VI, where it can be

observed that all the fatalities, and most of the serious postoperative complications, occurred in those operated upon over 48 hours after onset

TABLE VI
RELATION OF MORTALITY AND DELAY IN DIAGNOSIS

	Fatalities	Survivals	Nonfatal Complications
Total	5	14	6
Less than 2 hours	0	2	2 (relapse malaria)
2-24 hours	0	8	1 (wound dehiscence)
24-48 hours	0	1	1 (pneumonia)
			1 (relapse malaria)
Over 48 hours	4	2	1 (pneumonia)
			1 (subphrenic abscess)
Unstated	1	1	

One case died three hours postoperatively of shock. One case died 16 days postoperatively of pneumonia. Another died of continued hemorrhage, and peritonitis, 12 days after an attempt at tamponade¹⁶

Other older methods of treatment, such as suture and enveloping the spleen in omentum, have occasionally been used successfully, but the treatment was splenectomy in every survival in this series.

Generous blood transfusion has been used only in the more recently reported cases, and is essential because of the preexisting anemia and high fever. Autotransfusion in traumatic rupture of malarial spleens has been used with good results⁷¹. Paracentesis as a method of diagnosis and preoperative autotransfusion has been used and may occasionally be feasible⁷². Prompt plasma or, preferably, blood transfusion may resuscitate moribund patients, such as ours, and enable diagnosis and operative intervention.

Adequate medical treatment of the associated malaria is essential. Intramuscular atabrine 0.4 Gm. reaches an effective plasma concentration within 15 minutes, which is maintained by 0.2 Gm. i. m. each four hours for six doses, and 0.1 Gm. i. m. or p. o. daily for seven days. This will promptly arrest, or prevent, relapse which, even if not present, is so likely to occur postoperatively. Intravenous quinine must be given slowly, and is more toxic to an already strained cardiovascular system. It offers no advantages over the atabrine treatment outlined.

Although better medical and antishock treatment may improve the surgical mortality, the death of two-thirds of the cases without operation indicates that the greatest need is for accurate and early diagnosis.

CONCLUSIONS

1 The 65th case of spontaneous rupture of a malarial spleen reported since 1917 is described and the other cases reviewed.

2 Spontaneous rupture of the spleen occurs with all species strains and in all stages of malaria, but chiefly in active "benign" tertian (*P. vivax*).

3 The clinical picture, diagnosis and mortality of spontaneous splenic rupture in paretics is contrasted with that during malaria occurring in normals. In paretics, sudden "malarial shock" and peripheral collapse may be due to spontaneous rupture of the spleen even when the patient complains of no

pain, is afebrile, and the abdominal findings are negative. The clinical picture in nonsyphilitics is more typical of findings noted in traumatic rupture of the spleen. However, the abdominal pain is variable, the spleen is usually not palpable, abdominal spasm is moderate, so that the diagnosis was seldom made early, or preoperatively, in this series.

4 Pathologic findings in our case illustrate how reticular and endothelial hyperplasia obstructs venules and sinuses and causes the interstitial and subcapsular hemorrhages that frequently lead to rupture.

5 Treatment of choice is urgent splenectomy. However, energetic chemotherapy of active malaria is vital. Circulatory adjustments to preexisting anemia, fever and active infection demand prompt restoration of blood volume.

6 With earlier diagnosis, blood transfusion and antishock treatment more cases will be operable, and the present high mortality lowered.

Addendum Photomicrographs were kindly photographed by Dr Stanley L. Rea, of the Department of Pathology of Tulane University Medical School, New Orleans, Louisiana.

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PENETRATING WOUNDS OF THE CEREBRAL VENTRICLES*

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IN 1918, Cushing¹ reported a series of 30 cases of wounds of the ventricle, with six recoveries. He stated that "one of the most serious complications of penetrating brain wounds is the opening of the ventricle or the traversing of the ventricle by a missile or by bone fragments." Autopsy reports showed that 48 per cent of his patients died of infection, 26 per cent died from hemorrhage either subdural, intracortical or intraventricular, and the remaining 26 per cent died from either extensive intracranial damage or pneumonia. All these cases were débrided without widely opening the dura and by the method of blindly irrigating the tract of the missile. The average time-interval between injury and operation in Cushing's series was 25 hours, with extremes being five and 72 hours.

Haynes² has recently reported a series of 100 cases of ventricular injury. In 77 operated cases, the mortality was 33.7 per cent, with 10.3 per cent incidence of infection. He classified penetrating wounds by the size of the missile and damage incurred. Wounds with narrow tracts, produced by small missiles, he treated "by blind suction and irrigation through either the brain needle or long glass aspirator until the ventricle is reached."

This report is based upon 50 consecutive cases of verified ventricular penetration proved by inspection of the opening into the ventricle either at operation or at postmortem examination (Table I). Thirteen (26 per cent) of these cases were operated upon primarily by us at the 21st General Hospital (U S Army). There was no selection of cases, and surgery was not denied because of moribund condition. One patient died before operation, 24 hours after he was wounded.

Thirty-one cases (62 per cent) were inadequately débrided at forward installations and were reoperated by us one or more times because of infection or retained foreign bodies. Fourteen (28 per cent) of these had retained bone chips or metallic foreign bodies lying within the ventricle which required removal. There were five proved cases of ventricular penetration which were operated upon at other installations with recovery. Over-all mortality rate was 30 per cent (15 cases), of which 60 per cent was due to infection, and 40 per cent to vital brain damage.

Only two cases returned to combat duty, their reassignment being dictated by the gravity of the tactical situation at the time.

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CASE REPORTS

Case 1—A 25-year-old French-Arab soldier was wounded on May 13, 1944. He was admitted to our hospital 18 hours after injury, in stupor, with a penetrating wound of the right temporal region. Roentgenograms demonstrated a 3-cm bone defect, with a shower of bone fragments and two small metallic fragments deep in the *right* parietal lobe and a metallic fragment in the *left* parietal lobe just beyond the midline. At operation, after retraction of the right temporal muscle, a mass of necrotic brain and clot

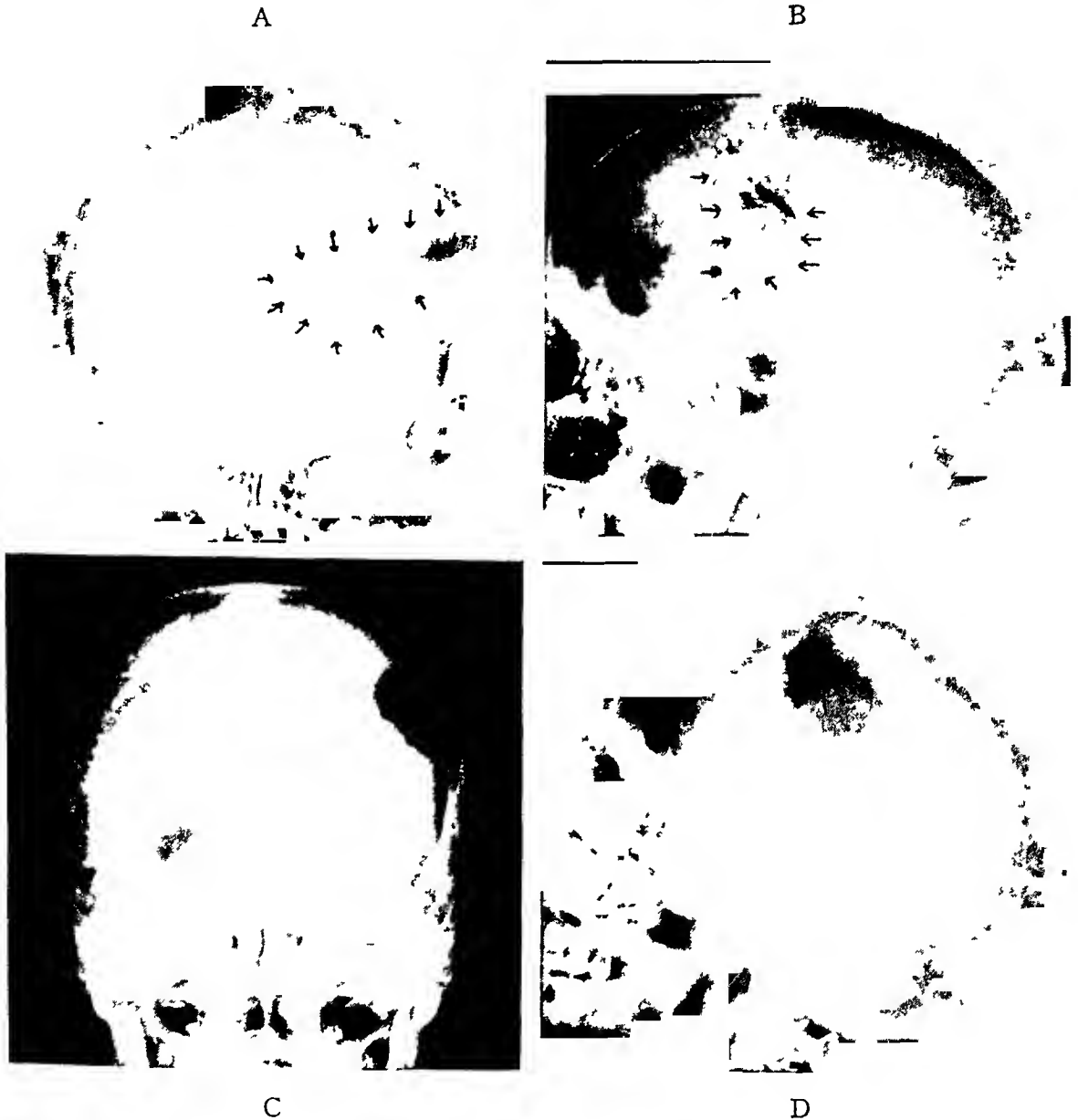


FIG 1—Case 2 (a) and (b)—Postero-anterior and lateral roentgenograms showing a penetrating wound in the left parietal bone, with numerous indriven bone fragments, which extended through the anterior horn to the falx.

(c) and (d)—Roentgenograms made after operation. Patient had temporary aphasia and hemiparesis of right arm. Returned to duty 26 days after injury.

gushed out through a 1.5-cm dural defect. Retractors were inserted into the tract and all damaged brain and bone chips were removed. The tract traversed the body of the right ventricle and one group of bone fragments was removed from the ventricle. The tract was followed for a depth of 7 cm, there was no indication to go through to the

opposite side to remove the metallic foreign body in the left parietal lobe. As débridement was carried out, the hitherto pulseless brain began to pulsate freely. After operation, the patient had temporary weakness of the left arm and face, and had low grade pneumonia. He improved rapidly, getting up on the 9th day. Paresis of the arm and face cleared completely within two weeks. Because of the tactical situation, and the soldier's great desire to return to his regiment, he was sent back to combat duty on June 1, 1944.

Case 2—An Arab who was admitted January 30, 1944, 48 hours after injury. He had a tangential left fronto-parietal wound, and showed weakness of the right arm and face and aphasia. Operation consisted of debridement with removal of 15 indriven bone fragments (Fig 1). The tract extended into the anterior horn of the left ventricle, and the falx was visualized at the end of the tract. Tight closure was effected after mobilization of the scalp and use of a modified Isle of Man incision. The wound healed *per primam*. Within 48 hours, sensory aphasia disappeared. Right arm weakness persisted for two weeks, when motor speech returned. He returned to duty on February 25, 1944.

TABLE I
ANALYSIS OF 50 CASES OF PROVED VENTRICULAR PENETRATION

	Total	Infection	Deaths	Death Due to Infection	Death Due to Brain Damage
Primary operation at 21st G H	13 (+1)	2	4 (+1 Pre-op)	0	4 (+1)
Primary operation Forward	36	31	10	9	1

TIME INTERVAL (HOURS) PRIOR TO SURGERY

	Minimum	Maximum	Average
Primary at 21st G H	5	96	39
Primary at Forward Hospital	3	29	15

CASES PRIMARILY DÉBRIDED

There were 13 cases which were operated upon primarily by us (Table I). They were admitted to the hospital at intervals varying from three to 96 hours after wounding, with half the cases arriving within 24 hours after being hit. The average time-interval between injury and operation was 39 hours. Of the 13, there were four deaths (30 per cent). The time intervals between injury and operation in these cases were 12, 23, 31 and 36 hours, respectively. Necropsy demonstrated that death was attributable to damage to vital centers.

There were no deaths from infection, and there were only two cases in which infection developed. One in which the scalp was closed under too great tension developed an abscess in the tract, in the other an abscess formed around a metallic foreign body and leaked into the ventricle. Both cleared up promptly after adequate surgery. Details of these two cases follow.

Case 3—A 29-year-old soldier, was struck in the right parietal region by a mortar shell fragment, on November 14, 1944. On admission to the 21st General Hospital, 17 hours later, he was comatose. The left side was spastic and there were bilateral pathologic toe signs. Through a 3-cm wound in the right parietal region, brain and clot protruded. Roentgenograms showed a fracture in the right parietal bone, with multiple indriven bone chips, in addition there was a large metallic foreign body in the midline at the level of the lateral sinus (Fig 2).

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Operation was performed 18 hours after injury. The right parietal wound was debrided. Under direct vision, a forked tract of necrotic brain, clot and bone fragments was followed through the posterior part of the right lateral ventricle, through the occipital lobe, to the tentorium. Through a hole in the tentorium, necrotic cerebellar tissue exuded, and there was considerable bleeding coming from the posterior fossa. A suboccipital craniotomy was then done. Macerated anterior lobe of the right cerebellum

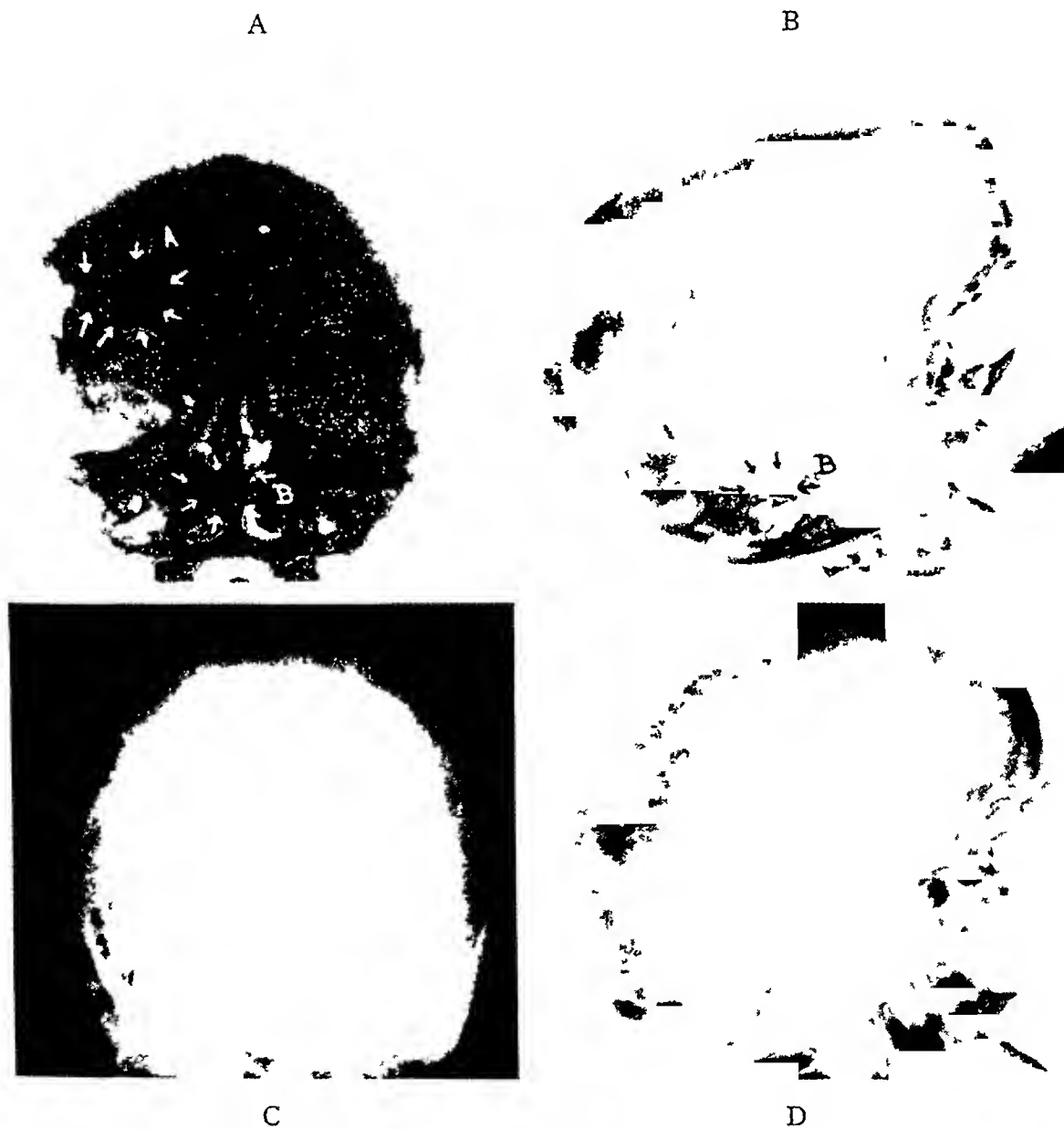


FIG 2—Case 3 (a) and (b)—Preoperative films, showing wound of entry in right parietal bone. Bone fragments driven deeply into the parietal lobe (arrows labeled A). A large metallic fragment is present in the midline beneath the tentorium (arrows labeled B).

(c) and (d)—Postoperative films showing parietal and occipital bone defects, bone fragments and metallic foreign body have been removed.

was sucked away. There was a tract leading from the hole in the tentorium to the rostral part of the vermis. Just caudal to the aqueduct, the metallic foreign body was found, directly in the midline, and was removed. Both wounds were closed tightly. Because of loss of skin in the parietal region, a scalp flap was fashioned and rotated to effect closure. By undermining further anteriorly, it was possible to close the donor site.

as well. This proved to be an error, since it resulted in too much tension on the suture line. Chemotherapy was begun immediately.

Following operation, the patient's condition improved and he began to respond. The cerebellar incision healed *per primam*. The parietal wound, however, became inlacerated at its central portion, because of too great tension at the suture line. Aspiration beneath the skin flap showed slightly purulent fluid, examination of which showed numerous pus cells, and gram-positive rods which were thought to be *B. subtilis* after culture. Penicillin was injected locally. Six days after operation, the patient's condition deteriorated. His neck became stiff, and a frank cerebrospinal fluid leak was present through the parietal wound. Skin edges were spread and penicillin was injected through the opening, using 10,000 units every six hours. Two days later, with evidence of an increasing infection, secondary craniotomy was done. The infected tract was sucked out and the ventricle wall was found to be covered with exudate. This was removed. A pocket of foul-smelling pus communicating with the ventricle was evacuated. Penicillin was instilled and the wound was closed. This time, the donor area of the rotation flap was not sutured, thus, good closure over the wound was obtained without tension.

Five days after secondary craniotomy, the donor area was covered with a full-thickness skin graft. The wound healed without further difficulty. The patient's subsequent course showed steady improvement, complicated only by left otitis media and laryngeal diphtheria. The latter complications necessitated delay in evacuation. He was evacuated, February 7, 1945, two and one-half months after his last operation. Examination at that time showed considerable *witzelsucht*, left homonymous hemianopsia, bilateral myasthenia, marked ataxia of the right arm and leg, and staggering gait.

Case 4—A 21-year-old officer, was struck by mine fragments on May 15, 1944. Evacuation was delayed, and no definitive treatment was given. On admission, May 19, 1944, he was drowsy and the neck was very rigid. There was marked papilledema on the left. The right eyelids were swollen shut. There was an extensive area of contusion and laceration of the right frontotemporal region. The left arm was weak. There was an unbridged wound of the left foot.

Roentgenograms (Fig. 3) showed a fracture of the right orbital ridge and a defect at the sphenosquamosal suture line. There were several small metallic fragments in the right temporal region, one larger fragment just anterior to the right mastoid, and another piece of metal in the occipitoparietal region near the midline.

Operation was performed on May 19, 1944. A defect in the right orbit was found and debrided down through a tear in the orbital capsule. This defect did not extend intracranially. After retracting the temporal muscle, a defect in the anterior part of the squamous bone, just above the zygoma, was visualized. This was enlarged and retractors were inserted into the mouth of a tract which ran posteriorly and medially. Necrotic brain and clot were sucked out. The tract was followed into the temporal horn of the ventricle. The opposite wall of the ventricle was visualized and found to be bruised by the course of one of the fragments. No attempt was made to go beyond the far wall of the ventricle, nor to remove the fragment in the occipitoparietal region. After hemostasis was secured, the wound was closed tightly.

The patient was placed on sulfadiazine, and he began to improve. A mild otitis media developed on the right, which cleared up after removal of the large metallic fragment from the posterosuperior portion of the auditory canal. The head wound healed well, but on the fifth day the patient began to complain of severe headache, and the temporal defect became tense.

On May 24, 1944, the wound of entry was reopened. The tract leading to the ventricle was found to be grossly clean (smears and cultures subsequently reported negative). Accordingly, this wound was closed. A perforator opening was then made in the right parieto-occipital region at a point thought to be near the retained foreign body. At a depth of 3 cm, an abscess was found and very foul pus was aspirated. Gram-positive rods were seen on smear.

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Roentgenologic examination was repeated, for better localization of the foreign body, and two days later, the fragment was removed. It lay in a pocket containing a small amount of pus and was surrounded by necrotic brain. The perforator opening was closed. The patient again did well for about five days, but then began to get drowsy, and

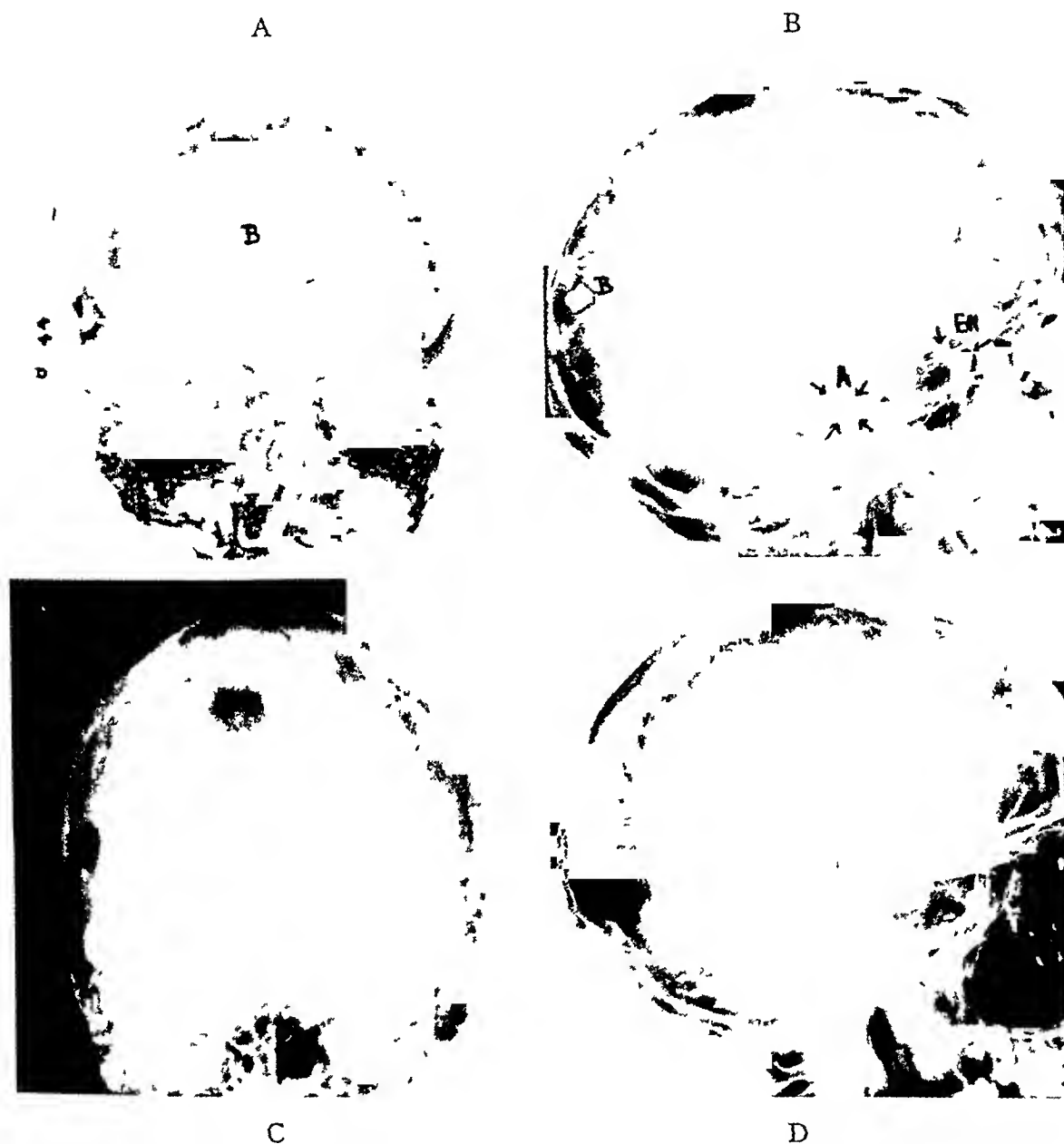


FIG 3—Case 4 (a) and (b)—Preoperative films showing entry wound, frontotemporal (EN and arrows), numerous small metallic fragments, one large fragment (A and arrows) just anterior to the right mastoid, one fragment (B) in the parieto-occipital region near the midline. The latter was found to be associated with a *Clostridial* abscess which communicated with the ventricle and was removed at a second stage. (c) and (d)—Final postoperative films before discharge, showing the temporal bone defect, the metallic fragments in the right parieto-occipital and mastoid regions have been removed.

showed evident signs of increased pressure. On May 31, 1944, following ventriculography, the right occipitoparietal bur-hole was reopened, and a large quantity of pus gushed out. Through the previously-created dural defect, retractors were inserted and a tract sucked out. The walls of the tract were covered with thick exudate, and the tract was found to communicate with the lateral ventricle. After evacuation of the tract, 10,000 units of

penicillin were instilled. The wound was closed with silk, leaving a narrow corrugated rubber drain, which was removed after two days. (This was contrary to our usual practice, but at this time, we were still fearful of *Clostridial* infection.) Bacteriologic examination showed the organism to be *C. sporogenes*. After removal of the drain the wound was completely healed in ten days.

Following this operation, the patient's course was very satisfactory. Convalescence was delayed by the wound of his left foot. This was closed secondarily on June 18, and the patient was then allowed to get up. Examination showed a temporal field defect in the left eye with central field intact. Vision in the right eye was limited to light perception, due to detachment of the retina and vitreous hemorrhage. Hearing on the right was 6/20, on the left 20/20. There was slight weakness of the left arm, but fine hand movements were present.

He was evacuated on July 14, 1944. Letters were received at frequent intervals. There has been no recrudescence of infection as late as 20 months after operation. Vision has improved to the point where this man is able to play as excellent a game of golf as before his injury, and he leads his customary active life on his farm.

CASES PRIMARILY OPERATED UPON IN FORWARD INSTALLATIONS

Of 36 such cases which reached our hospital, 31 required secondary operation. Primary operations were performed at intervals ranging from three to 29 hours after injury, with an average time-interval of 15 hours. Among the 31 there were 12 cases of abscess, three of meningitis, and 14 cases of ventriculitis and meningitis; there were two cases with retained bone chips without clinical evidence of infection. There were ten deaths in this group of cases (32 per cent), with infection being the responsible cause in nine (Table I).

FACTORS IN MORTALITY

Analysis of our own cases as well of those of others, reveals that there are three factors which are of paramount importance in the production of the morbidity and mortality following wounds of this type.

I *First is introduction of infection, with resultant ventriculitis*. This is one of the most feared complications of ventricular penetration, and is borne out in our cases. Treatment should, therefore, be directed towards removal of the potential source of infection and eradication of infection if already present.

Case 5—A 26-year-old soldier, was wounded in the left frontal region by a shell fragment, on March 5, 1944. Craniotomy was performed 24 hours later at an Evacuation Hospital, a 7-cm tract was cleaned out, sulfanilamide was instilled, and the wound was closed, with a drain. Chemotherapy was instituted. On removal of the drain on the following day, leakage of cerebrospinal fluid was noted.

On admission to the 21st General Hospital, March 11, 1944, there was a defect in the lower part of the wound, with sanguinopurulent drainage. On compression of the upper part of the wound, gas escaped through the defect. Cultures of the pus were reported positive for staphylococcus and streptococcus. Roentgenograms (Fig 4 a, b) revealed a large frontal defect, involving the supra-orbital ridge and left frontal sinus, with extensive linear fracture lines. There was a large nest of retained bone fragments in the left frontal region, in a position corresponding to the anterior horn of the ventricle. Lumbar puncture revealed elevated pressure (310 mm of water), the fluid was cloudy and contained 250 cells.

On March 14, 1944, secondary operation was performed. A mass of pus and

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necrotic brain was found and removed. Retractors were inserted through a tract 8 cm long and 1.5 cm wide, which led directly to the anterior part of the lateral ventricle. Four bone chips were removed from the depths of the tract. The wound was closed. There was steady improvement for five days, at which time the lower end of the wound

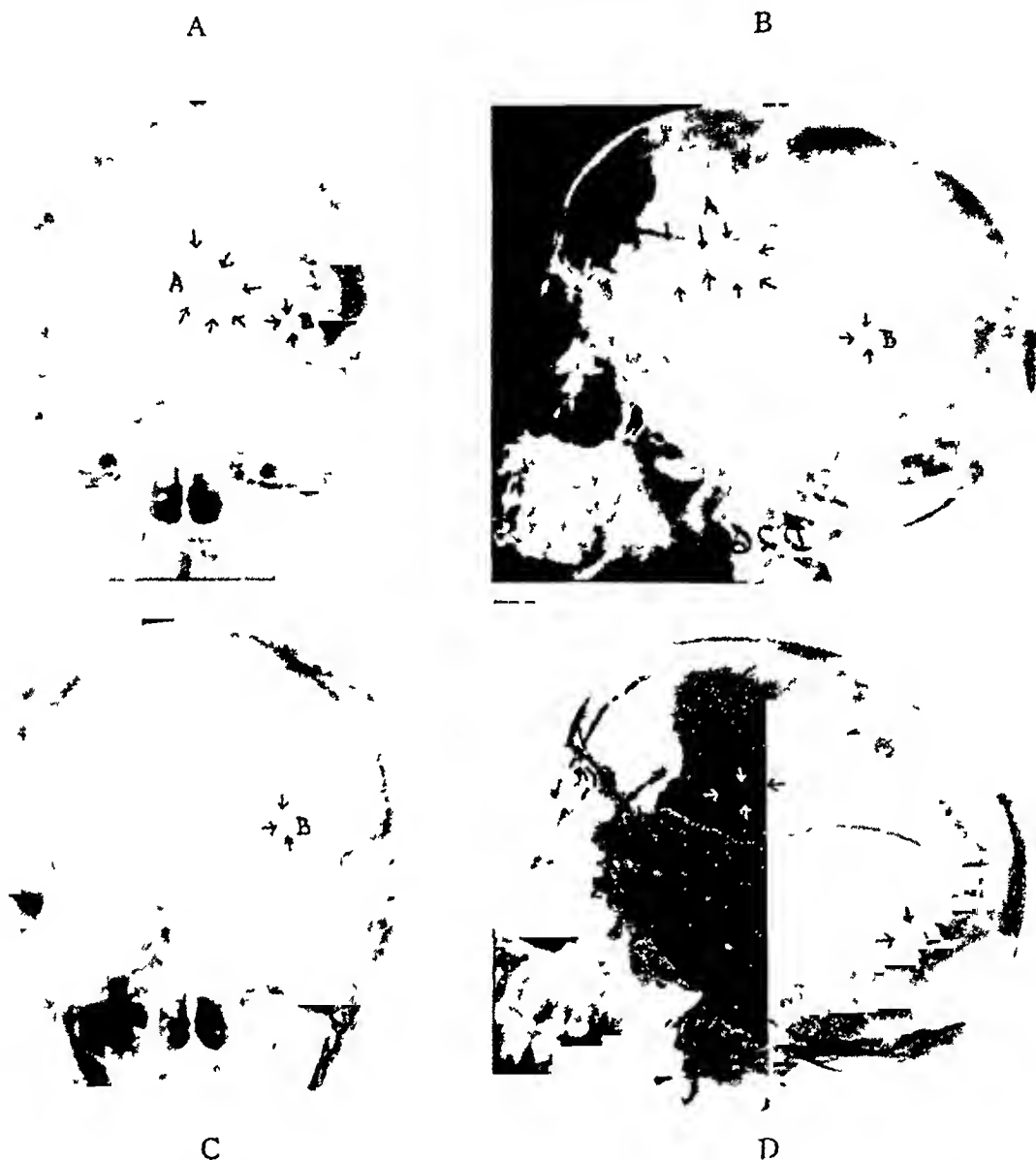


FIG 4—Case 5 (a) and (b)—Roentgenograms on admission, prior to secondary debridement. There is a large frontal bone defect, with numerous retained bone fragments (A and arrows) driven in to the anterior horn of the ventricle. The barely perceptible fragment outlined by arrows and labeled B was overlooked.

(c) and (d)—Postoperative films show the large nest of bone fragments in the frontal lobe replaced with silver clips. The small fragment (B) which was overlooked in the preoperative films, has shifted position and now lies in the occipital horn.

was spread, and 10 cc of pus escaped. Purulent drainage increased and the patient became aphasic. Roentgenograms (Fig 4 c, d) revealed that the nest of bone chips had been removed. Reoperation revealed an abscess just beyond the limits of the previous exploration.

The patient's course was steadily downhill. Repeated smears and cultures after March 14 showed gram-positive rods. Signs of meningitis progressed. Bilateral post-parietal bur-holes were made on April 4, and 10,000 units of penicillin was injected into

each ventricle daily. In addition to parenteral penicillin and sulfadiazine, this patient received 155,000 units of penicillin intraventricularly. He died on May 12, 1944. Autopsy revealed extensive encephalomalacia of the left hemisphere, basal ganglia and thalamus. There was marked left frontal cerebritis and lateral ventriculitis.

On reviewing this case, it is apparent that incomplete débridement, with retention of bone fragments, was responsible for the infection. The lack of available penicillin during the first days of his hospitalization cannot be blamed. After very careful reexamination of the roentgenograms, it was found that one barely perceptible bone chip was overlooked in favor of the prominent nest of bone in the anterior horn. In comparing the films before and after removal of this mass, it can be seen that a chip lying in the posterior parietal region was still present and had shifted position (Fig 4 b, d). This obviously lay in the occipital horn. In view of this finding, we believe that, had we not overlooked this bit of bone, its removal through a separate approach might have resulted in a happier outcome.

Case 6—A 20-year-old French soldier, received bilateral parieto-occipital wound on November 15, 1944. Twenty-five hours later, operation was performed at an Evacuation Hospital. Because of bleeding from the lateral sinus, débridement was not completed. The wound was packed with gauze. Five days later, without any further attempt at debridement, secondary closure, with a transverse skin relaxing incision was done.

On admission, November 25, the patient was disoriented. His neck was stiff. There was complete amaurosis. The transverse wound over the occiput was found to be broken down and infected, and the relaxing incision was likewise infected. There were bilateral occipital lobe herniae. Roentgenograms (Fig 5a, b) revealed numerous indriven bone fragments. Sulfadiazine therapy was instituted and severe cellulitis of the scalp was reduced to some extent with wet dressings.

On November 28, the wound edges were excised and spread. The bone defect was enlarged and the longitudinal sinus exposed. The latter had been completely destroyed for a distance of 2 cm just anterior to the torcula. Two large bone fragments were removed from its stump and bleeding was controlled. Two tracts in the left occipital fungus were cleaned out to a depth of 3 cm. Because of the overwhelming scalp infection, this procedure was planned solely to remove bone chips and establish adequate external drainage. Therefore, the wound was left open.

There was steady improvement on sulfadiazine therapy until December 9, when high fever and cervical rigidity returned. Penicillin was given intrathecally. Under local treatment, the scalp became much cleaner and another operation was performed on December 16. Just lateral to the left occipital fungus a tract was found which led directly into the occipital horn of the lateral ventricle. After debriding the tract, the body and temporal horn were well-visualized. The ventricular fluid was cloudy and the wall was smooth and glistening. The choroid plexus was coagulated, clipped and excised. It was thought best not to close the dura with a graft at this time. A single-pedicle scalp flap was mobilized to cover a 12 x 4 cm defect, and the scalp was closed after instilling 10,000 units of penicillin into the ventricle.

Signs of meningitis persisted, despite daily intrathecal injection of 20,000 units of penicillin. Spinal fluid cultures were consistently positive for *Staphylococcus albus*. On December 28, the patient became worse. Lumbar puncture did not affect the tension of the occipital defect. Right ventricle puncture through an anterior bur-hole readily decompressed the defect however. It was evident, therefore, that a block existed at the aqueduct, or below. Penicillin was injected into the ventricle daily. By January 6, the

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block had disappeared and the patient was greatly improved, but large amounts of fluid continued to collect beneath the scalp defect. On January 16, the wound was reopened. The porencephalic cavity in the left occipital lobe measured 60 cc, and there was an 8-mm opening into the occipital horn (Fig 5c, d). The tract was clean except for a small amount of exudate at the opening into the ventricle. The dura was closed tightly with a fascia lata transplant, and the scalp was closed in layers with silk.

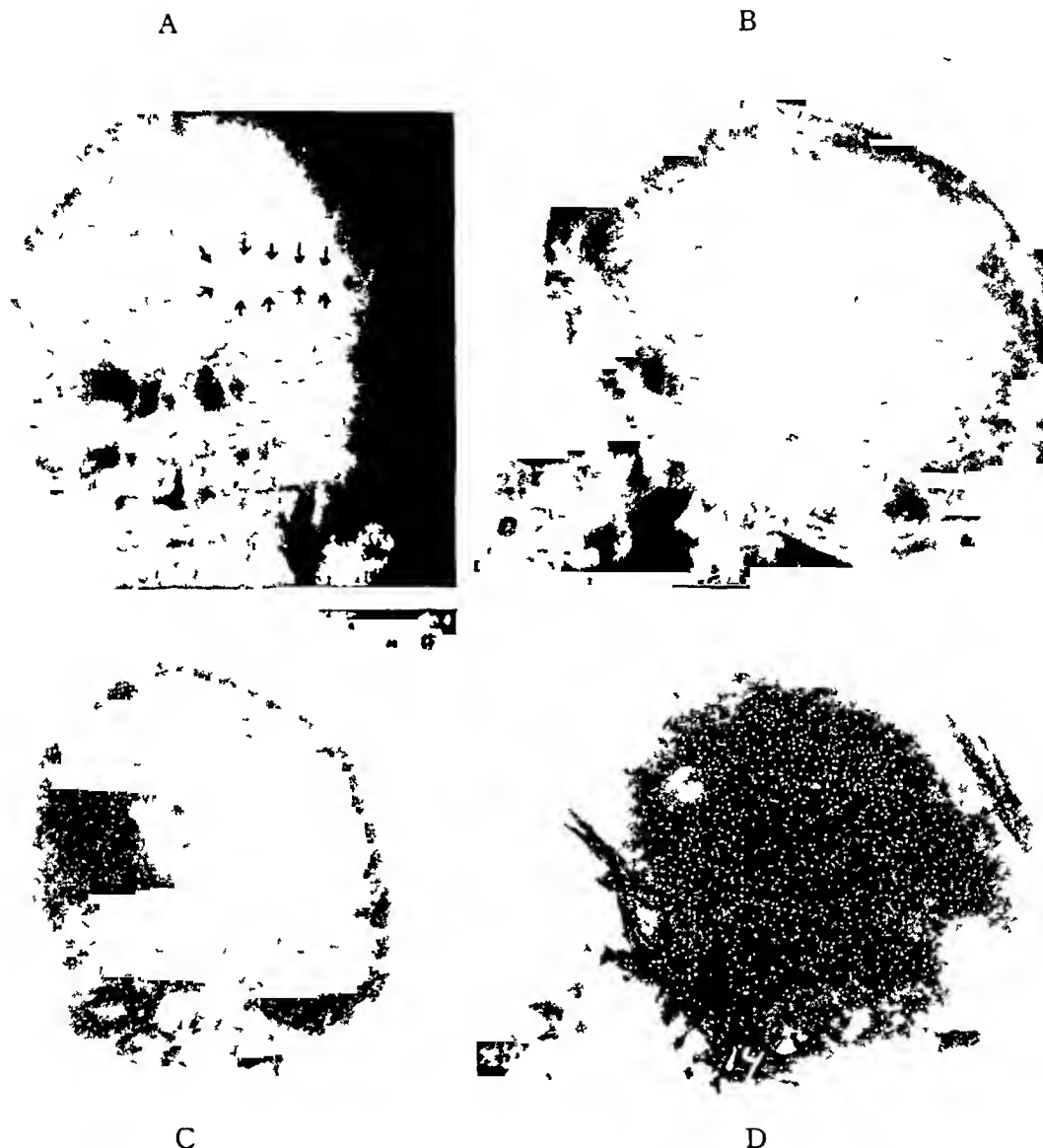


FIG 5—Case 6 (a) and (b)—Films before secondary débridement, showing numerous indriven bone fragments and entry wound (EN)

(c) and (d)—Ventriculograms after débridement of tract which communicated freely with the left occipital horn, at débridement, the left choroid plexus was removed. Films show air in the occipital tract and air in the ventricles, silver clips are seen at point of communication between porencephalic occipital lobe and the left ventricle.

Following this last operative procedure, the patient showed steady improvement, interrupted, however, by repeated flare-ups of staphylococcus meningitis. These responded to penicillin therapy, and fluid remained clear after February 10. He became able to get about, and there was light perception in both eyes. The wound was solidly healed. When the patient was evacuated to a French Hospital on March 7, neurologic examination was negative, except for visual loss.

II *The second factor, or complication, is that of hemorrhage into the ventricular system* Aggressive efforts must be made to arrest or prevent hemorrhage and to remove as much blood and clot from the ventricles as possible

We have relegated ventricular hemorrhage to a position of less importance than that of infection because in our series of cases of penetrating ventricular wounds varying in time after injury from a few hours to several days, ventricular hemorrhage was by no means as frequent a complication as was infection. The probable reason for this is that these cases died soon after injury and never got back to us. The fact that there were so few such cases in our series, in no way lessens the importance of this complication or in any way modifies the recommendation that the clot should be removed from the ventricle under direct vision.

Case 7—A 27-year-old soldier received a penetrating wound in the right midparietal region, on December 22, 1944. He had immediate paralysis of the left arm and leg, but was able to talk on admission to an Evacuation Hospital, where operation was performed 26 hours after injury. The surgeon noted that 200 cc of clot and pulped brain were removed along with bone spicules. After instilling 50,000 units of penicillin, the wound was closed. Meningitis developed in six days, and treatment with intrathecal penicillin was instituted.

On admission to the 21st General Hospital on January 5, 1945, the patient was aphasic. There was complete left hemiplegia with loss of fine discriminatory and position sense on the left. There was bilateral papilledema. The wound was broken down and infected over an area 3 cm long near its center. Roentgenograms showed several large bone fragments, deep in the parietal lobe, with one fragment shifting in position (Fig 6 b, c).

On January 7, 1945, secondary craniotomy was performed. After excising the infected scalp, and removing the dural graft, the mouth of a tract was found in protruding brain. Retractors were inserted into the tract and a large mass of old clot and necrotic brain was evacuated. The resulting cavity was 60 cc in volume and communicated, at a depth of 5 cm with a very large defect in the superolateral wall of the right lateral ventricle. The ventricle was very large and distended with an organized clot. On removal of the clot, the entire body of the ventricle was visualized, and explored through the large opening in its wall. Four bone fragments were found lying in the ventricle. One sizable bone fragment was found adjacent to the foramen of Monro. It was thought that the dilatation of the ventricle was the result of the large clot rather than blockage of the foramen by the bone chip. After instillation of 20,000 units of penicillin, the dura was closed with a fascial transplant. The scalp was closed by means of a rotation flap, and the donor area was covered with a full-thickness skin graft.

The wound healed *per primum*, and the patient improved steadily, with rapid clearing of papilledema. Postoperative roentgenograms, however, revealed one retained bone fragment which shifted in position between the temporal horn and body of the ventricle (Fig 6d). Since cultures made at our first operation were positive, it was decided to reoperate and remove the remaining fragment. After a short delay, due to the patient contracting laryngeal diphtheria, this was done on January 20, through a temporal approach.

All wounds healed promptly. Aphasia began to clear within a week, at which time the patient informed us that he had been left-handed as a child. About one month after our first operation, the parietal wound became puffy at one point, this was opened and a small cotton pledget was removed from beneath the galea. No further complications occurred. He was evacuated on March 21, 1945. At that time, eye grounds were normal.

WOUNDS OF CEREBRAL VENTRICLES

There was left homonymous hemianopsia. Speech was improved, but by no means normal. The left arm was still paralyzed, considerable power had returned in the left thigh.

III *The third factor, that of associated damage to vital centers, is the least amenable of all to improved therapy.* A fairly large percentage of deaths

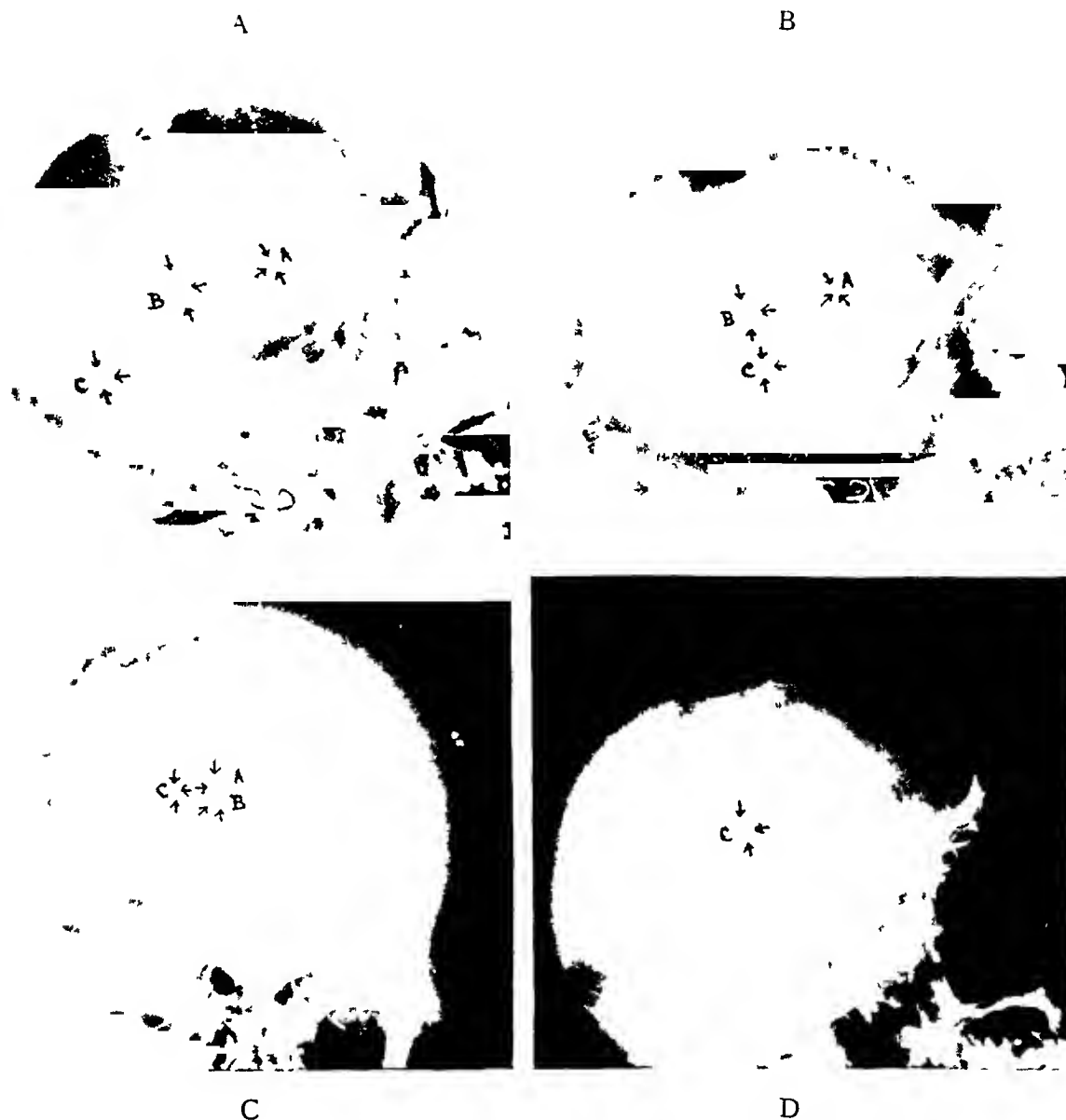


FIG 6—Case 7 (a) and (b)—Lateral views, prior to secondary debridement, showing three groups of bone fragments, A lies at the foramen of Monroe, B lies in the body of the ventricle, and C is shown shifting in position from the occipital horn to the temporal horn.

(c)—Anteroposterior view. At operation, a large clot was found filling the body of the ventricle.

(d)—Lateral film, after secondary debridement. Compare with (a) and (b). The fragment which was originally visualized in the temporal and occipital horns, is retained and can be shifted into the body of the ventricle. Bone fragments labeled A and B in the preoperative films have been removed, together with intraventricular clot.

from this cause was expected and most series of cases will bear this out. However, since many patients with vital center damage did not live sufficiently long to allow for operation, they formed only a modest group among our cases.

That some such cases may survive long enough to undergo extensive surgery, only to expire days, or even weeks later, must be recognized. This is exemplified by the following case, in which the patient withstood the effects of intraventricular hemorrhage, but succumbed to a lesion of the brain stem.

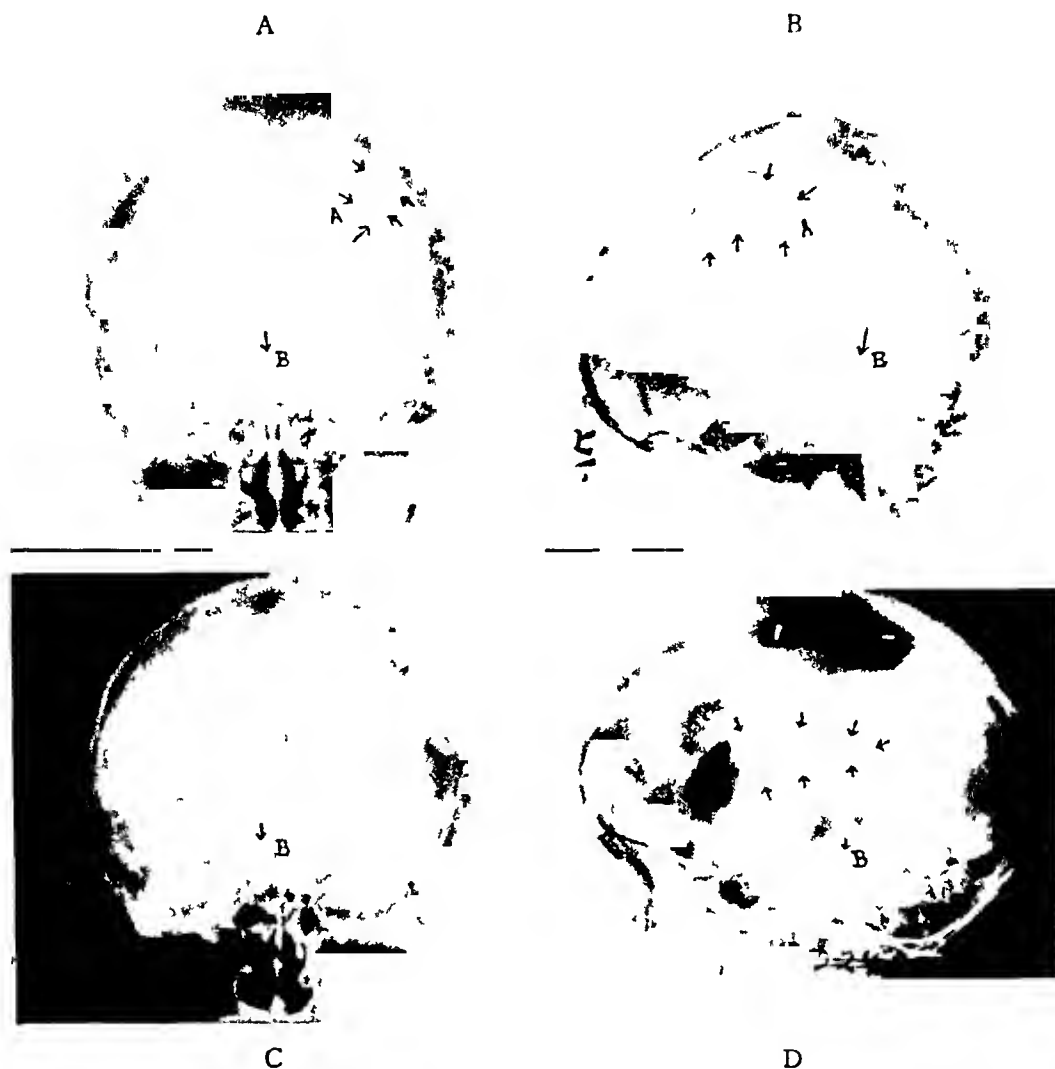


FIG 7—Case 8 (a) and (b)—Original preoperative films showing a large metallic fragment and indriven bone chips (A) and a small metallic fragment (B) in the brain stem.

(c)—Postero-anterior view after debridement, showing two defects in the left frontal and parietal bones, and retained metallic fragment in the brain stem.

(d)—Lateral ventriculogram, showing anterior and temporal horns of left lateral ventricle, arrows outline a large defect in the body of the ventricle, corresponding to intraventricular clot.

Case 8—A 23-year-old soldier suffered left frontal and parietal penetrating wounds on May 31, 1944 (Fig 7 a, b). He became unconscious immediately and remained comatose. At an Evacuation Hospital, debridement was performed within 24 hours after injury. The patient's condition became so bad that complete operation had to be abandoned. The scalp was closed.

WOUNDS OF CEREBRAL VENTRICLES

The patient remained in coma. He was transferred to the 21st General Hospital on June 4, 1944. There was a 6-cm left frontal and a 20-cm left parietal sutured scalp wound. Both wounds were tense and did not pulsate. Roentgenograms showed the underlying bone defects, with two small bone chips in the parietal lobe, and a metallic fragment in the midline near the base (Fig 7 c). After removal of the skin sutures, the scalp wounds began to gape, and the parietal wound broke down with discharge of foul pus.

On June 7, 1944, the parietal wound was opened widely. The purulent cerebral hernia was amputated and a necrotic tract was followed for 3 cm. The brain remained very tense. A ventricle needle was introduced and a large quantity of clot and old blood was aspirated from the ventricle. The brain began to pulsate. Because of the patient's continued poor condition, it was thought unwise to explore the ventricle under direct vision, but to attempt to tide him over with ventricle punctures. Cultures showed staphylococcus on both aerobic and anaerobic media.

The patient's condition remained poor, and he again showed evidence of pressure. On June 10, 1944, ventricle puncture was done, and 40 cc of old, brown blood mixed with clot was obtained. Since the brain was still tense, it was felt that a good deal of clot was still present and further ventricular aspiration was futile. Ventriculogram (Fig 7 d) showed a large defect in the dilated left ventricle. It was obvious that, despite the patient's poor condition, removal of the clot was necessary. Accordingly, retractors were introduced down to the ventricle. A large, old clot, surrounded by a thin membrane was found in the dilated ventricle. The membrane was found to be attached at several points to the choroid plexus. Clot and membrane were removed. One large piece of clot, separate from the main mass, was plugging the foramen of Monro. After removal of clot, the walls of the tract through which retractors had been introduced fell away, leaving a cavity 6 cm deep by 3.5 cm in width, communicating freely with the dilated left ventricle. Closure was carried out, using fascia lata transplant for the dura.

There was no change in the patient's condition, and he died on June 13. Autopsy showed the tract to be clean, the left ventricle was collapsed and free of clot or exudate. Extending through the substance of the brain on the left side from the mesencephalon into the pons was a hemorrhagic area 1 cm in diameter and 5 cm long. The metallic fragment was found lying in the center of a necrotic area 2 cm in diameter in the very center of the pons.

PATHOLOGY

The pathology of wounds involving the ventricles is the same as that seen with all types of wounds produced by high explosive shell fragments or bullets, and little needs to be added to what has already been written on this subject. There is, first of all, a shattering of the skull, depending upon the size of the missile involved and the angle at which it strikes. The dura is torn jaggedly to an extent which depends on the size and velocity of the missile, the comminution of the skull, and the number of indriven bone chips and foreign bodies. The tract is filled with pulped brain, blood clots, bone and metallic fragments. The opening into the ventricle may be of any size, dependent upon the size of the missile and angle at which it has traversed the ependyma. The ventricle may be filled with bright blood or clot, plus bone chips, hair, *etc*, or the opening may be only a tiny slit which seals off under pressure of surrounding edematous brain.

With incomplete débridement, if an abscess in the tract develops, it may leak into the ventricle to produce ventriculitis, or if the ventricle itself is not cleaned out, infection may develop primarily within the ventricular system.

Failure to effect hemostasis from a bleeding choroid plexus may produce clots in the entire system or on a single side with a block of the foramen of Monro. Similarly, infection within the ventricles, producing a shaggy exudate over the ependyma and choroid plexus, may extend throughout the system and may lead to foraminal block.

DIAGNOSIS OF VENTRICULAR PENETRATION

We have not been able to diagnose ventricular penetration by symptomatology. Signs are dependent upon the area of the brain involved rather than penetration of the ventricular wall. That these patients are usually acutely and seriously ill is to be expected from the amount of cerebral tissue which must be damaged in order for a missile or bone fragments to reach the depth at which the ventricles lie. On the other hand, a few cases, with a narrow tract of brain damage and little hemorrhage, may present a deceptively excellent general appearance. A diagnosis of ventricular penetration may be suspected when radiographic examination reveals a tract outlined by bone chips leading toward the normal position of the ventricle, but this is by no means certain. Occasionally, one can make a diagnosis with reasonable certainty, when films show a radiopaque foreign body which shifts with movement of the head.

TREATMENT

Treatment of ventricular wounds is no different from that of other penetrating wounds of the brain, even though they are more serious by virtue of the depth of the wound. In a previous paper³ we have reported our early experiences with primary and delayed treatment of penetrating wounds of the brain, and the actual technic will not be discussed here. As further experience accumulated, radical surgery, with closure, became accepted procedure in almost all cases, despite gross evidence of infection. There are some features of ventricular wounds however about which more should be said.

Routine stereoscopic roentgenograms (anteroposterior and lateral) of the skull are of particular value in cases suspected of ventricular wounds. This will aid in diagnosis not only by giving the dimension of depth to foreign bodies but will also assist in the detection of a shift of a foreign body. Further accurate visualization of the pattern of a group of bone fragments may confirm suspicion of ventricular penetration.

Patients suspected of having a ventricular wound should be given top priority for surgery, for the greater the delay the greater is the risk of infection or clot in the ventricles. Operation should be performed promptly, preliminary treatment for shock or dehydration having been started as soon as possible.

It should be reemphasized here that the crux of the treatment of these wounds is adequate, thorough, aggressive débridement of the entire tract including the ventricle, under direct vision. It is not reasonable to assume that adequate débridement of all pulped brain, clot, hair, bone and metal can be done without visualization of this material. Not only will débridement be

inadequate but the danger of producing extensive damage outside the missile tract or of producing further hemorrhage is ever present. In our experience, following the tract has not been difficult, for as the narrow malleable retractors are placed deeper and deeper and pulped brain and clot removed, tension falls rapidly and the tract may be spread easily without doing further damage to the brain.

In late secondary cases, with abscess and ventriculitis, again we believe that radical complete débridement with primary closure is essential. Since one cannot hope to cure a ventriculitis until the source of contamination is removed, the abscess is evacuated under direct vision and the shaggy exudate is thoroughly sucked-off the wall of the tract. Likewise, the ventricle is inspected, and clot and bone fragments are removed. Metallic foreign bodies are removed if readily reached, without inflicting additional trauma. Occasionally, metallic fragments may require removal by drastic means, but in most cases they are innocuous. Penicillin is instilled just prior to closure.

Closure of the dura has been accomplished in almost all our cases by pericranial, temporal fascia or fascia lata grafts, both in early and late secondary cases. Just as in uncomplicated penetrating brain wounds, we have found that the danger of loss of a graft through infection in a thoroughly débrided wound is negligible. On the other hand the presence of a water-tight dural closure minimizes the danger of a ventricular fistula, should a scalp closed under too much tension give way. Too, if the dura is not closed there is a tendency for ventricular fluid to collect under the widely mobilized scalp to inhibit galeal-pericranial apposition, and to constantly keep the suture line under tension. If great care is not taken the wound will spread from the tension and a fistula may develop, with disastrous results from infection.

We believe that fresh pericranium or fascia is the material of choice for water-tight closure. Fibrin film was used as a dural substitute in two cases with a widely open ventricle, fluid continued to accumulate beneath the galea until the film was removed and replaced with fascia.

CHEMOTHERAPY

In World War II there have been two factors which have been instrumental in the marked lowering of morbidity and mortality rates in head wounds. First, is complete débridement, and, second, is chemotherapy. There is no drug which will ever replace complete débridement in penetrating wounds of the brain, and so much drug has been given indiscriminately that it is doubtful whether we shall ever be able to determine accurately the effectiveness of each. That chemotherapy has its place in the treatment of penetrating head wounds in general, and of ventricular wounds in particular goes without saying. We have used sulfadiazine and penicillin, alone and in various combinations, and both have proved to be effective parenterally.

In penetrating ventricular wounds, we have generally instilled 10,000 to 20,000 units of penicillin into the ventricle before closure. In cases in which signs of ventriculitis are not present, this has sufficed. If, on the other hand, definite ventricular infection was found at operation, penicillin in amounts

from 20,000 to 50,000 units in spinal fluid have been administered daily until all signs of infection disappeared. If there was some contraindication to the lumbar route of administration, as for example internal hydrocephalus, it was injected directly into the ventricles through the bone defect or through perforator openings made especially for this purpose. In our experience, intraventricular injection of penicillin in the presence of infection has resulted in no deleterious effects.

SUMMARY AND CONCLUSIONS

An analysis of 50 proved cases of wounds of the cerebral ventricles is presented. Ventricular penetration was verified by direct inspection at the time of operation or at postmortem examination. There were 15 deaths in the group, including one patient who died before operation.

In a series such as this, in which some of the initial operations were performed under varied circumstances by several different surgeons, statistical analysis means little. However, there are some conclusions which may be accurately drawn.

Of 13 cases operated upon primarily, there were four deaths, all of which were due to brain damage. Of 36 cases which were operated upon at forward hospitals, 31 required reoperation, there were ten deaths in this group, of which nine were due to infection.

Factors in mortality and morbidity have been reviewed, with illustrative case histories. In those cases of ventricular injury which survive long enough to reach surgery, infection is at least as responsible as vital brain damage as a cause of death.

Treatment consisting of prompt and thorough débridement of the entire brain tract including the ventricle may be expected to lower the mortality rate. Such débridement should be carried out under direct vision. Infected cases should be handled in the same way, with removal of débris, retained bone fragments and pus, and closure of the wound.

Direct instillation of penicillin at the time of operation, plus penicillin parenterally, and sulfadiazine are effective only when combined with necessary surgery.

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SOME EFFECTS OF EXPERIMENTAL THERMAL BURNS ON VASCULAR ENDOTHELIUM EMPLOYING A PERFUSION TECHNIC IN ANESTHETIZED DOGS

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THE PROBLEM

CONVENTIONAL METHODS for producing burns in physiologic investigations have been relatively crude insofar as they affect many vital structures simultaneously. For example, Keeley, Gibson and Pijoan¹ applied the flame of a Bunsen burner to the skin of the thorax in anesthetized dogs, and judged the character of their burns by the uniformity of blanching obtained. Underhill, Kapsinow and Fisk² applied a heated iron with a fixed temperature to skin surfaces for varying periods of time. Wilson, Jeffrey, Roxburgh and Stewart³ inserted an active electrode with a flat disk into the subcutis beneath the platysma to burn all components of skin equally. Field, Drinker and White,⁴ and others, have immersed the feet of anesthetized experimental animals in water at 100° C for varying periods of time to create standard reproducible burns. By all these technics the epithelium, nerve endings, nerve fibers, accessory glands with their ducts, loose connective tissue, blood vessels, lymphatics and subdermal structures are affected unselectively. It is true that a burn obtained by immersion of a part in hot water at a known temperature for a definite number of seconds, is readily accomplished and easily repeated. Furthermore, this type of burn is directly comparable to human experience in military and in civil life. Yet the fact stands out in the minds of all who have attacked the problem, that such burns and their possible general effects represent different degrees of heat attack upon many different tissues. At the surface, heat coagulation will occur, and destruction of cells — red, white, epithelial, and endothelial—of smooth muscle, of striated muscle, *etc*, will be accomplished where the heat is greatest, and will grade to the center of the part where no damage may be done. Experimental burns readily simulate human experience, but do not give opportunity to relate burn damage both locally and generally to uniformity of attack upon any tissue in the injured part. Assuming—and it is not an idea unjustified by other experiments—that injury to vascular endothelium may be the most fundamental lesion in burns, it has been the idea behind these experiments that if the leg of an anesthetized dog was suddenly perfused with a hot solution of 6 per cent gum acacia, and after a few minutes of uniform vascular and adjacent injury the perfusion was stopped and the circulation restored to normal, there would be a degree of uniformity in the effects of heat not attainable through surface burning by the

methods which have usually been employed. Certainly, the use of such a technic must first affect the vascular endothelium, and must show to some degree whether injured endothelial cells readily contribute substances to the blood capable of causing dangerous systemic effects.

A method has, therefore, been developed for perfusing the vascular tree of the hind leg of an anesthetized dog with hot solutions, a method permitting return to the normal circulation of the part when the perfusion was ended. It has been possible to observe the local effects and to record the absence of general effects as the immediate results of these burns.

The original idea behind these experiments was that injury produced by hot perfusions might leave the vessels of an extremity specifically damaged and it would then become possible to make observations on such matters as return to reasonably normal permeability of capillaries, characteristics of contraction and dilatation of vessels on appropriate stimulation, fibrin formation, and other issues in the little explored physiology of blood vessels turning toward normal in inflamed tissue. This field of observation was not reached but data have been gathered on the immediate effects of these thermal burns on capillary permeability and on the absence of immediate systemic effects from the burns.

EXPERIMENTAL TECHNIC

Mongrel dogs, ranging from 12 to 22 kg in weight, were used. No preliminary studies as to hydration, nutrition, blood protein levels, or anemia were carried out. Sodium nembutal was administered intravenously for general anesthesia, 32 mg per kg being given initially, with supplemental doses to maintain full anesthesia at all times.

The right external carotid artery was cannulated for recording arterial blood pressure. The external jugular vein was exposed for giving intravenous fluids and taking blood samples. A thermometer was inserted subcutaneously into the abdominal wall for temperature recordings. A single intravenous injection of 5 per cent dextrose in Ringer's solution (20 cc per kg of body weight) was given each dog early in the day, and one-half hour later a blood sample was taken for hematocrit determination.

The dog lay upon his back in a wooden cradle. This was arranged on a table in such fashion that the cradle's height could be adjusted above the table and by means of ropes and pulleys the dog could be tilted into a nearly upright position, a convenient arrangement for immersing the dog's hind extremities in warm baths just before and during perfusions, and for facilitating the measurement of leg volumes by water displacement.

With the hind legs outstretched, an incision was made longitudinally over the femoral vessels (Fig 1) on the medial aspect of the thigh. The sartorius was retracted laterally, and the adductor longus medially. The femoral artery and vein, the long saphenous artery and vein, the popliteal artery and vein and the short saphenous vein were exposed. The femoral nerve was spared. With this dissection completed, lymphatics of both the hind legs on the lateral

aspect of the calves just above the ankles were cannulated, and samples of lymph were collected until a constant range of readings for protein concentrations was obtained. Strap tourniquets were placed around each thigh and held close to the groins by the aid of brass cleats which were tied to the wooden cradle. The long saphenous artery was clamped close to its junction with the femoral artery and cannulated (Fig 1). The short saphenous vein close to its junction with the popliteal vein was clamped and cannulated. Photographs of both hind feet were taken.

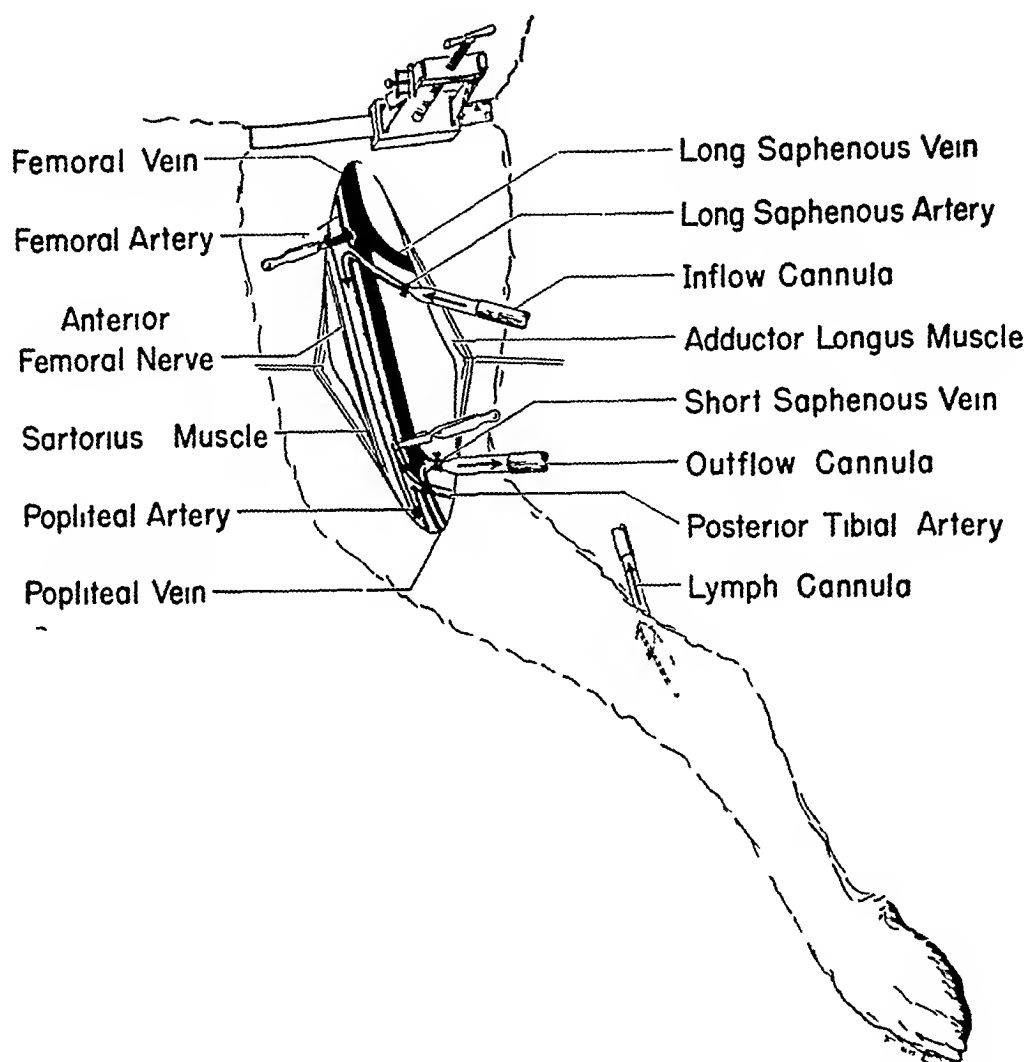


FIG 1 —Diagrammatic representation of the dissection used in the perfusion experiments

The dog's cradle was then elevated 18 inches off the table, tilted to a nearly vertical position, and volumes of both hind legs were determined by a water displacement method. Upon returning the cradle to the horizontal position, the hind legs to the ankle were immersed for 15 minutes in water heated to 50° C. This was done to obtain maximum vascular dilatation in the extremities before perfusion. The cannula in the long saphenous artery was attached to a supply bottle of normal saline and 6 per cent gum acacia solution adjusted to a pH of 7.0 with sodium hydroxide and ready to deliver the perfusate under 160 mm Hg of air pressure. The acacia solution in a water bath was held at a

fixed temperature, varying for different experiments from 38° to 75° C. An acacia solution was used for the perfusate, since it could be heated at random without the formation of precipitates and since it could be relied upon for the brief period of the perfusion to maintain the osmotic balance dependent normally upon the blood proteins. A kymographic tracing of arterial blood pressure was made at suitable intervals in each experiment.

To begin the perfusion, the arterial clip was shifted from the long saphenous artery to the femoral artery, and the perfusate began to flow up the long saphenous and down the femoral artery. To be certain that the leg was entirely isolated from the animal's own circulation, a tourniquet, shown at the top of Figure 1, was tightened strongly at the groin. This was always done in the perfused leg, and in many cases upon the opposite control leg so that the same period of vascular occlusion as regards normal blood supply would be experienced upon both sides. As is the case in human experience on occlusion of blood flow to the extremities, no alteration in the subsequent volume of the control leg was noted in such periods of asphyxia by blocked blood flow as have been used in these experiments. With the tourniquet upon the perfused leg tight, which required but a few seconds, the venous clip was shifted from the short saphenous vein to the popliteal vein. Gum acacia solution was run in for periods ranging from 45 to 20 minutes. The inflow temperature was recorded close to the inflow cannula. Outflow temperature and minute volume outflow readings were recorded at the delivery cannula three to four times during a single perfusion. The dog's subcutaneous temperature was taken before, during, and after the perfusion. At the end of the perfusion, the clips were shifted back to their original positions in the same order as above. The tourniquet was removed. A moderate amount of venous bleeding was allowed before shifting the venous clip, until such time as colorless or pale pink perfusate became dark red again, to prevent shunting the acacia solution contained in the leg vessels into the general circulation.

With the dog returned to his own circulation, the feet were removed from the hot baths, the cannulated vessels were tied off, the wound closed, and the feet were placed in nearly horizontal positions. Four- to 36-hour periods of observations were carried out following perfusions and included: Foot volumes, lymph flows, lymph protein concentrations, dog's temperature, arterial blood pressure, pulse and respirations, blood hematocrits, photographs of the hind legs, skin temperatures on the hind feet, and selected skin biopsies. The perfused vessels together with controls from the opposite leg were explored at the end of the experiment to observe the extent of subcutaneous edema and the ease with which bleeding occurred upon making incisions in the skin, and for any evidence of thrombus formation or damage to the vascular endothelium. Selected vessels were taken for microscopic study.

EXPERIMENTS

After some experience with the method, the question arose as to whether the local dissection and the application of a tourniquet contributed significantly

PERFUSION TECHNIC IN BURNS

to changes in vascular permeability with subsequent swelling of the extremities. To answer this inquiry, both hind legs of two dogs were dissected, cannulae inserted, and the feet immersed in hot baths. Tourniquets were applied for 10-, 15- and 20-minute periods without perfusions, no swelling, not even transient, occurred in any foot. In 11 dogs, the vessels were dissected and a tourniquet applied to the control leg in a fashion similar to the one which was perfused. None of these control legs showed edema, increase in lymph flow, or changes in lymph protein content, while the perfused legs showed all the changes.

TABLE I

RELATIONSHIP BETWEEN DEGREE OF SWELLING OBSERVED IN DOGS' FEET AND INFLOW TEMPERATURE OF PERFUSATE WHILE PERFUSION PERIODS ARE UNDER 10 MINUTES AND PERFUSION RATES ARE OVER 25 CC PER MINUTE

Dog No	Weight	Period of Perfusion	Rate of Perfusion	Inflow Temperature	Outflow Temperature	Degree of Swelling
	Kg	Min	Ml/min	C°	C°	
1	19	6	38	45	39	0
2	17	6	42	46	41	0
3	15	8.5	28	46.5	41	0
4	17	7	30	48	41.5	0
5	16	9	48	51	41	0
6	15.6	4	136	51	46	0
7	14.4	9.5	68	52	43	+
8	19	4.5	90	53.5	47	+
9	14.2	5.5	80	54	44	0
10	14	8	46	55	45	++
11	13.5	5	110	55	48	++
12	19	5	88	56	49	+
13	16.3	6	68	56	48	0
14	13.9	6.5	78	62	48	++++
15	15.3	5.5	36	64	47	+++
16	17.1	7	84	68	47	+++
17	14.7	6.5	50	68	50	+++
18	18	6	78	70	50	++++
19	16.4	6	34	75	50	++++

It is a natural speculation as to whether the perfusion with attendant anoxia contributed to our results. Several dogs were perfused with gum acacia solution heated to 38° C for periods ranging from 4.5 to 13.5 minutes. One dog, perfused for 13.5 minutes with a very slow rate of flow (18 Ml per minute), showed swelling, probably due to obstructed outflow. All dogs perfused under 10 minutes with flow rates better than 25 Ml per minute showed no swelling.

In consequence of the above, perfusions were done for periods ranging from 4 to 9 minutes (average 6.04 minutes in 22 experiments), and flow readings ranging from 34 to 136 Ml per minute (average 67 Ml per minute in 22 experiments) were achieved. Table I is of interest with regard to these factors. When the rate of flow was brisk and the period of flow not too prolonged, the incidence and magnitude of swelling was in direct relation to the temperature of the perfusate. It is evident from this table that more than half

TABLE II
EXPERIMENTAL PROTOCOL OF DOG 12 WITH RIGHT LEG PERFUSED

Time	Comments	Nem- butal 5%	Dog's Temp	Foot Volume		Lymph Protein		Temperature of Foot Bath		Temperature of Perfusate		Perfusion Rate	Arterial Blood Pressure	Hematocrit
				Right	Left	Right	Left	Right	Left	Inflow	Outflow			
		Cc	C°	Cc	Cc	Gm %	Gm %	C°	C°	C°	C°	MI/min	Mm Hg	%
8 30	Dissection started	14												
11 00		2				2 32	1 21							
11 30	I V 300 cc													
12 15		2				1 87								32
12 15														
1 15	Photos taken		36	210	185	1 76	1 37						216	
1 33		2												
1 35	Feet in hot bath							49	48					
1 55	Perfusion started		35							30	36		220	
1 57										50	41			
1 59										55	46	82		
2 01	Perfusion stopped		35					48	48	56	49	88	178	
2 17						1 26	1 17						180	
2 26				215	205									
2 37		2				1 46	1 20							
3 04														
3 17						1 38	1 44							
3 45	Photos taken	2		240	190								184	29
3 50														
4 30			35			1 61	1 28						192	
4 45						1 51	1 51							
4 50	Photos taken													29
5 00	Sacrificed			220	185								195	

of the 13 dogs which were perfused with solutions below 56° C showed no swelling at any time Five dogs showed very mild swelling which frequently was transient and nearly subsided while the animals were under observation Every dog perfused above 60° C displayed marked swelling when, as in all

TABLE 111
EXPERIMENTAL PROTOCOL OF DOG 19 WITH RIGHT LEG PERFUSED

Time	Comments	Nem- butal 5%	Dog's Temp	Foot Volume		Lymph Protein		Temp of Foot Bath		Temp of Perfusate		Perfu- sion Rate MI / min	Arte- rial Press- ure Mm Hg	Hema- to- crit %
				Right	Left	Right Gm %	Left Gm %	Right C°	Left C°	In- flow C°	Out- flow C°			
9 00	Dissection started	10												
11 45	1 V 250 cc					2 82	3 05							
12 00		2												
12 30						2 93	2 82							28
1 30	Photos taken	1 5	36	170	150									
1 35	Feet in hot bath							48	48					
1 54		1 5	36					48	48				172	
1 55	Perfusion started													
1 56										50	36		108	
1 57										68	38	34		
1 58			36					50	48	71	48			
1 59										73	48	32		
2 00			36							74	50		198	
2 01	Perfusion stopped							48	49	75	50	34		
2 15				195	160	2 79	2 77						176	
3 05						2 95	3 10						168	36
4 00		1 5*	36			3 20	2 56						164	34
4 50	Photos taken	1		240	160								166	
6 00						3 38	2 85						166	
7 30	I V 250 cc					3 48	3 15						164	42
8 30		1 5	35			3 36	3 01						166	
10 30	Photos taken	2	35	275	160	3 48	3 12						172	46
12 00		2	36 5			3 46	3 23						166	
3 00		2	37			3 22	2 80						166	47
4 45		1 5	36			5 21	2 80						168	
4 49						4 11	2 53						164	
6 30		2	37			4 83	2 36						162	
8 05		1 5	37			4 92	2 40						158	
9 30	1 V 250 cc	1 5	37	300	140	4 32	2 30						156	50
11 00	Plasma 250 cc	1 5				4 75	3 28						140	
12 15	Photos taken	1 5	37			4 10	3 10						136	51
1 00	Sacrificed													

cases, normal circulation was restored This was progressive while the animals were under observation

Complete data from two experimental protocols are given in Tables II and III, illustrating in the one case the meager and readily reversible changes when the perfused solution entered at 56° C, and in the other case the severe and progressive changes observed when the perfusion solution entered at

75° C The volume of the feet in both instances increased slightly during the immersion in the hot baths, but returned to normal fairly promptly on the control side. The volume of the foot perfused at 56° C continued to swell slightly for two hours following the perfusion and removal from the hot bath (Fig 2, A and B), subsequently the foot volume slowly returned towards



FIG 2—Photographs of both hind feet of Dog 12, illustrating mild and transient swelling of the perfused right foot (A) Just before, (B) 1.75 hours after, and (C) 3 hours after perfusion

normal during the next hour (Fig 2, C). On the extremity perfused at 75° C, however, the foot volume increased progressively during the 36 hours of observation following perfusion (Fig 3). The protein content of lymph collected from the two legs of Dog 12 showed no change on the unperfused side, while the protein content dropped and the rate of flow increased for two hours

on the perfused side. These changes were followed during the next two hours by a diminution in rate of flow and a reversion towards normal of the protein concentration. In Dog 19, on the other hand, the lymph protein content during the observation period steadily rose, simultaneously the flow increased and the color of the lymph became pink. Microscopic examination of the lymph revealed numerous free erythrocytes in small clumps. The systolic arterial



FIG 3—Photographs of both hind feet of Dog 19, illustrating the severe and progressive swelling of the perfused right foot (A) Just before, (B) 3.75 hours after, and (C) 22 hours after perfusion

blood pressure of Dog 12 was sustained throughout the experiment, and hematocrit measurements showed no significant alterations. Upon the introduction of the hot perfusate in Dog 19, there was a transient drop in systolic arterial blood pressure accompanying severe sensory stimulation, this was quickly restored before the six minutes of perfusion were completed. During the following 36 hours, however, there was a very gradual drop in blood pressure

and increasing hemoconcentration with a rising hematocrit. At the time of sacrifice of Dog 12, incision made into the dorsum of the perfused foot showed no subcutaneous edema and considerable free bleeding from transected blood vessels. No vascular thromboses were detected upon dissecting the major arterial and venous trunks. In Dog 19, on the other hand, incision into the dorsum of the perfused foot displayed copious amounts of subcutaneous edema and no free bleeding. Upon dissecting the major vessels there were freshly formed, friable clots in the femoral artery and popliteal vein.



FIG 4A—Microscopic view of skin biopsy from the perfused right hind leg of Dog 12, illustrating no changes ($\times 40$)

Pathologic studies were carried out on all experimental subjects. Selected skin biopsies were taken from the web space and dorsum of each hind paw. Transverse sections were made across segments of femoral and popliteal arteries as well as femoral and popliteal veins. These were fixed in Zenker's solution and stained with eosin methylene blue. In addition, segments of popliteal veins were slit longitudinally, washed with distilled water, stained on the endothelial surface with 10 per cent silver nitrate solution for one minute, washed again with distilled water, and fixed in 10 per cent formalin. By this technic, refined by O'Neill,⁵ the intercellular cement of the endothelium was visualized together with the geometric pattern of the endothelium.

PERFUSION TECHNIC IN BURNS

Microscopic examination of skin biopsies showed no abnormalities in the control legs and no changes in legs perfused from 4 to 9 minutes with the gum acacia solution heated up to 60° C (Fig 4A) Above this threshold of temperature or beyond 10 minutes' perfusion time, sections from swollen feet showed subcutaneous edema, congested capillaries, widely dilated lymphatics, and erythrocytes extravasated into the intercellular spaces (Figs 4, B, and 5) With the silver nitrate technique, the endothelial coat of veins from



Fig 4B—Microscopic view of skin biopsy from the perfused right hind leg of Dog 19, illustrating subcutaneous edema, congested capillaries, widely dilated lymphatics, and erythrocytes extravasated into the intercellular spaces (X 40)

control legs and from legs perfused for short periods of time at appropriately low temperatures appeared intact and uniformly symmetrical (Fig 6, A) Legs which had progressive swelling following perfusions above 60° C, on the other hand, showed a disruption of the geometric endothelial pattern with fragmentation and disappearance of lining cells (Fig 6, B)

One further consideration was the total amount of perfusate run in and recovered from the outflow cannula Total inflow readings ranged from 215 to

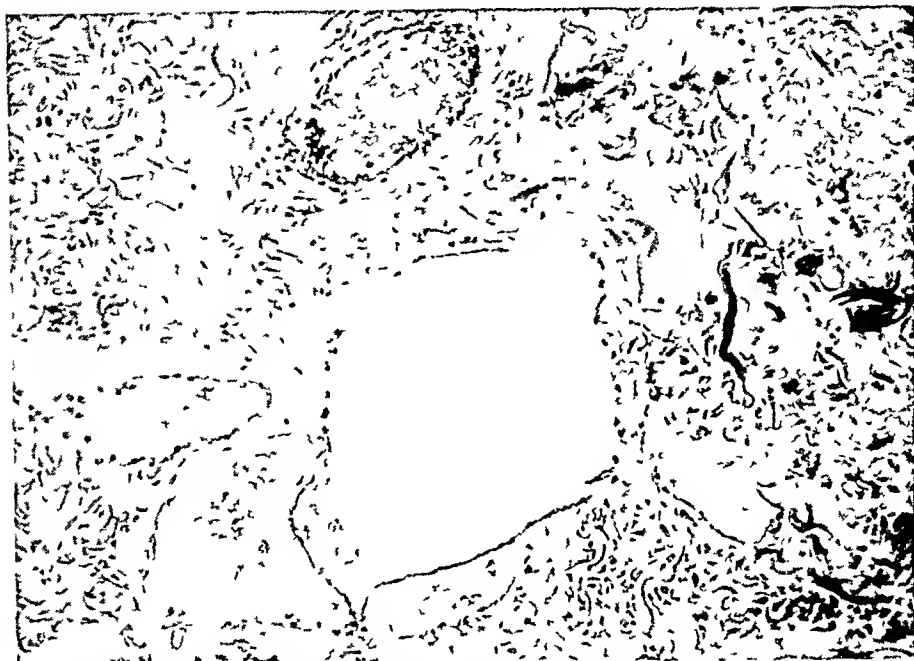


FIG 5—High-powered microscopic view of the skin biopsy from the perfused leg of Dog 19, emphasizing the wide dilatation of the lymphatics, congestion of the capillaries, and extravasation of erythrocytes ($\times 90$)

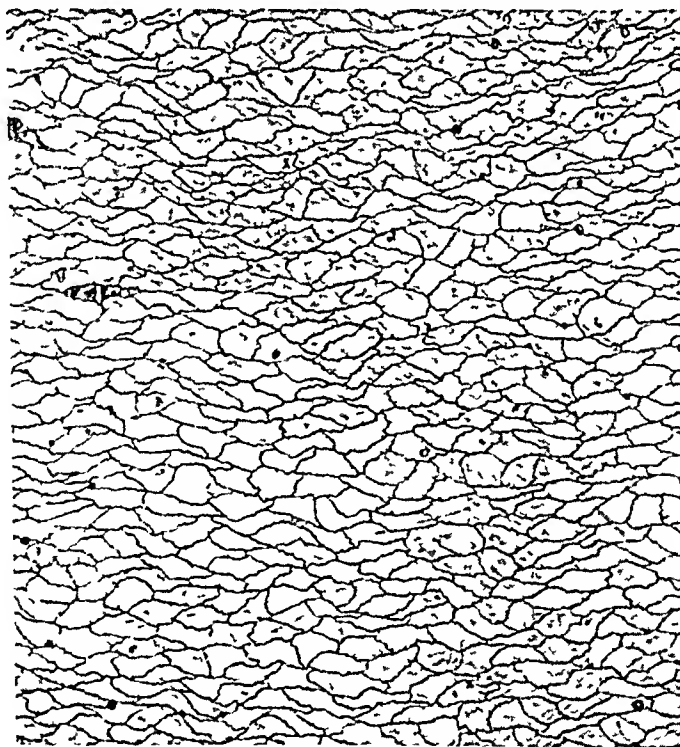


FIG 6A—Microscopic view of the endothelial pattern of the intact endothelium of the popliteal vein from the control leg of Dog 19 ($\times 60$)

520 cc (average 337 cc in 17 experiments), and total outflow readings ranged from 150 to 535 cc (average 320 cc in the same 17 experiments) In most instances the inflow and outflow were nearly equal, but in experiments in which the outflow was more or less than the inflow there was no correlation with the incidence of swelling

DISCUSSION —The data from these experiments can by no means settle the much debated problem concerning the etiology of the systemic effects of



FIG 6B—Microscopic view of endothelial pattern of the fragmented endothelium of the popliteal vein from the perfused leg of Dog 19 ($\times 60$)

thermal burns Like other workers,^{6, 7} we have no evidence of the existence of immediate shock under the experimental conditions described above Whether the systemic changes in blood pressure and hemoconcentration, as indicated in Table IV, are due to the release of toxic substances (Wilson, *et al*^{3, 8}) or are due to the shift in body fluids (Blalock⁹ and Harkins⁶), or both, continues to remain an unanswered question In view of the fact that several of our perfusion experiments were done under complete aseptic surgical conditions, we believe that neither bacteria nor bacterial toxins have contributed to our findings Aldrich¹⁰ has made clear, however, that bacteria play little role in burns during the first 36 hours, the longest time during which our animals were studied

In the investigation of the rôle of hypoxia and anoxia in these experiments, these findings are in general accord with those of Kellaway and Rawlinson¹¹

who perfused the isolated lungs of guinea-pigs with saline. Their perfusions were, however, carried out over six-hour periods, and they concluded that anoxia does not cause any gross injury to tissue cells and is unlikely to aggravate heat injury to any significant extent. Six per cent gum acacia solution was used in the experiments reported in this paper in order to provide the colloid osmotic pressure of normal circulating blood plasma. With this solution warmed to 37° C, it was found that perfusions for increasing intervals of time beyond 10 minutes were attended by increasing amounts of swelling. Within this time limit, however, hypoxia did not appear to alter vascular permeability.

In their third paper, Kellaway and Rawlinson¹² studied the effects of hot saline perfusions on the isolated hind limbs of guinea-pigs and the fore limbs

TABLE IV
RELATIONSHIP BETWEEN DEGREE OF SWELLING AFTER PERFUSION AND CHANGES IN
ARTERIAL BLOOD PRESSURE AND HEMATOCRIT

Dog No	Weight Kg	Arterial Blood Pressure			Hematocrit			Swelling
		Before Perfusion	End of Experiment	Net Change	Before Perfusion	End of Experiment	Net Change	
6	15.6	192	178	-14	35	40	+5	0
9	14.2	178	162	-16	31	25	-6	0
13	16.3	170	166	-4	28	36	+8	0
7	14.4	230	196	-34	30	32	+2	+
2	19	216	194	-22	32	29	-3	+
10	14	180	182	+2	20	33	+13	++
11	13.5	176	142	-34	28	31	+3	++
15	15.3	166	134	-32	31	36	+5	+++
16	17.1	220	156	-64	33	39	+6	+++
14	13.9	216	224	+8	30	49	+19	++++
18	18	168	144	-24	25	45	+20	++++
19	16.4	172	136	-36	28	51	+23	++++

of cats. Again their perfusions were carried out over periods lasting several hours. They washed the vascular tree free of blood constituents by running through approximately a liter of saline at a rate of 10 to 15 MI per minute, and then continued their perfusion for several hours at a rate of about 1 to 2 MI per minute, high rates of flow for simple saline solutions. Under more precise experimental conditions with an intact animal, it is indicated that the duration and rate of flow of the perfusion play a rôle in altering the permeability of the vascular endothelium as judged by the incidence of leg swelling, rate of lymph flow, and alterations of lymph constituents.

SUMMARY

1. A new method for perfusing the vascular tree of the hind extremity of the intact dog has been described. A solution of normal saline and 6 per cent gum acacia solution at a pH of 7.0 was the perfusate.

2 The results of employing this technic for the study of the effects of heat on the permeability of the vascular endothelium and neighboring structures locally are described and discussed

3 In addition, observations on the systemic effects of such burns on the animal generally are reported

4 A new method, from O'Neill's⁵ unpublished work, has permitted examination of the cellular pattern of the vascular endothelium

The authors wish to express their profound gratitude to Dr Cecil K. Drinker for his many helpful suggestions and sympathetic supervision while this work was being conducted in his laboratory

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HOMOGENOUS FETAL CARTILAGE GRAFTS TO BONE

AN EXPERIMENTAL STUDY

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PREVIOUS EXPERIMENTAL WORK with diced cartilage has proved that autogenous grafts survive transplanting and in some cases exhibit growth. Studies conducted here have confirmed these findings.¹ We observed viable cartilage three months after grafting into a long-bone defect in a rabbit. Replacement by bone was exceedingly slow. It was decided to investigate the reactions in adult long bone when a defect was repaired with diced homogenous fetal cartilage.

Fetal tissues have received considerable attention in recent years. Pure strains of cartilage cells from chick embryo were grown *in vitro* by Fischer² on embryo media for over three months. Fell³ was able to show that isolated fowl femora 5-6 days old had a capacity for self-differentiation and *in vitro* increased to three times their size with no change in gross proportions. Histologically, they had a normal cellular differentiation. She was able to show that a phosphatase was liberated *in vitro* and this enzyme was produced only when large hypertrophic cells were present.

In subsequent work Fell and Robison⁴ confirmed the need for hypertrophic cartilage cells in the production of phosphatase. They were able to observe osteogenesis in mandibular mesoderm around Meckel's cartilage of fowl by hanging-drop tissue culture methods.

This means that tissue culture methods have proven early cartilage has the propensity for self-differentiation *in vitro*, as well as the production of phosphatase.

Transplanted epiphyseal cartilage has also been studied. Early continental observers had suggested that when epiphyseal cartilage was grafted to a bony site it continued to grow. In fact, Straub's⁵ case of an epiphyseal bone transplant in a boy, with excellent clinical results 16 years postoperatively, strongly suggested this. Nevertheless, after intensive experimental study Haas⁶ was able to conclude that the epiphyseal cartilage plate loses its ability to produce length growth after transplanting. This was confirmed by Bisgard's⁷ work with goats.

Embryonic cartilage *in vitro* has the power to grow, to differentiate and to liberate phosphatase. Yet, when epiphyseal cartilage, itself actively growing and undergoing replacement by bone, is transplanted, some of these potentialities are lost. This study is an endeavor to ascertain the histologic reactions involved when healthy young fetal actively growing cartilage is transplanted into adult long bone.

FIG 1

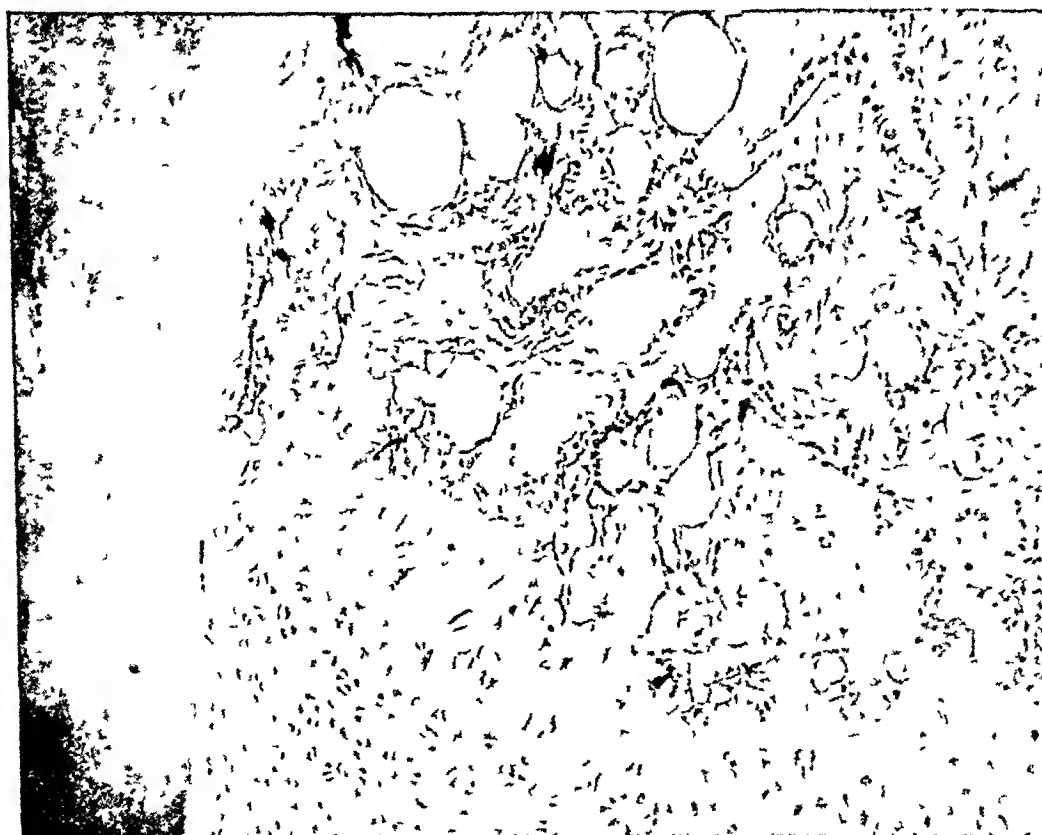


FIG 2

FIG 1—Four days postoperatively Several dices of fetal cartilage lie within the defect. Each is filled with deeply-staining cartilage cells, two or three to a lacuna. An ingrowth of connective tissue cells has begun to surround the dices.

FIG 2—One week postoperatively One corner of a cartilage dice is shown, evidently through an epiphyseal line, with solid cortical shaft bone beside the graft. Considerable cancellous bone is replacing the cartilage, which is invading in normal patterns.

FIG 3

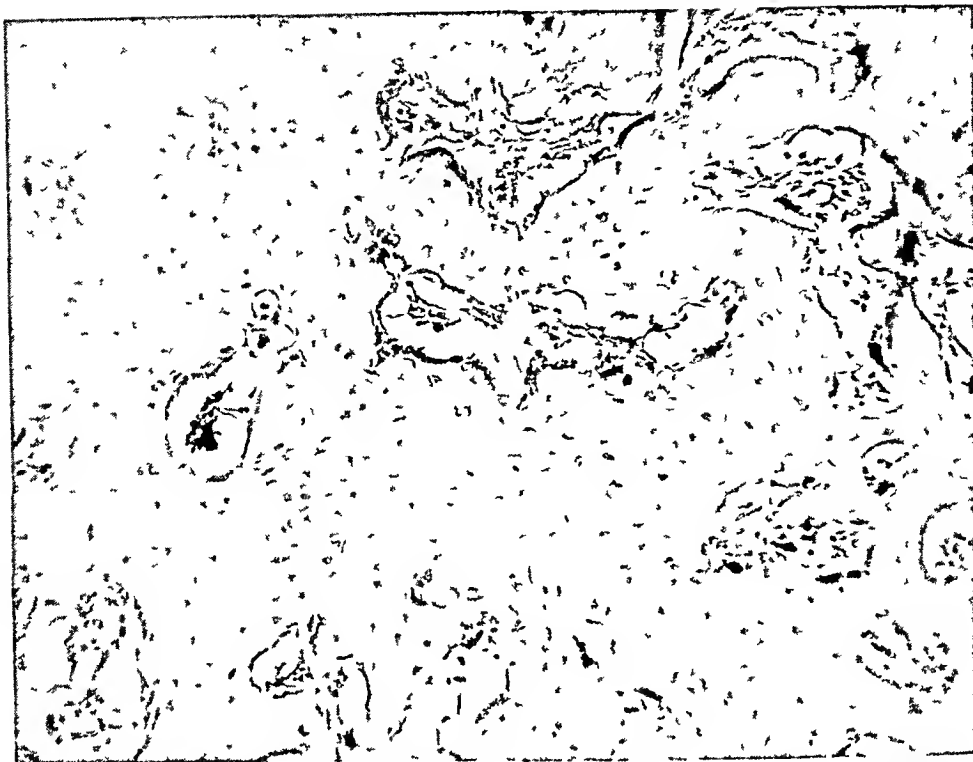


FIG 4

FIG 3—Two weeks postoperatively The dices of cartilage have been invaded by tongues of absorption. These tongues are partially occupied by deeply-staining cells and debris. The cartilage cells appear in enlarged lacunae, and most lacunae have only one cell within them.

FIG 4—Three weeks postoperatively. One corner of a dice of fetal tissue is seen surrounded by active cancellous bone. The chondrocytes are arranged in layers and flattened. Towards the line of ossification some lacunae are enlarged and empty and communicate with the medullary cavity.

Material—A supply of fetal material was obtained by removing uterus and feti from a near-term female rabbit. Under sterile conditions the long bones of the unborn rabbits were dissected out and the cartilaginous epiphyseal ends removed. These were diced into approximately 0.5 mm cubes and preserved in sterile saline solutions.

Method—The experimental animal was anesthetized and a long bone of the forelimb exposed. A defect, one-half-inch in diameter, was created on the cortex and extended into the medulla. No complete fracture of the bone was made. Into this defect the fetal cartilage dices were packed tightly and held in place by the periosteum and tendon of the limb. The incision was closed with black silk and collodion dressings applied. No immobilization was used, the animal being free as soon as consciousness was regained.

Fifteen such animals were used, and were sacrificed at four days, one week, and thereafter at weekly intervals. Sections were taken in the axis of the limb through the defect to show normal shaft on either side of the cartilage grafts. After decalcification they were stained with hematoxylin and eosin.

RESULTS

Four days postoperatively Many dices of cartilage are seen completely filling the defect. Each dice shows marked cellular activity, with lacunae well-filled with two or more cells, many of which are undergoing division. Surrounding each dice are ingrowths of connective tissue cells, growing parallel to the dice surface. There is no evidence of cartilage necrosis or reaction by the host to the homogenous material.

One week postoperatively Cartilage cells are still filling the lacunae but on one side, evidently the epiphyseal line, the process of ossification is continuing with large cystic-like lacunae being invaded by tongues of bone.

Two weeks postoperatively Dices of cartilage have lost their solid appearance and appear "motheaten." Defects throughout the matrix exist in the form of wide channels. These are lined with deeply-staining cells, running parallel to the wall. The cartilage itself is less cellular, the lacunae larger and incompletely filled by chondrocytes. Each cell stains deeply, many clinging to the lacunar walls, some pyknotic and a few round and pale. Some lacunae appear to be coalescing. Cancellous bone surrounds the dices.

Three weeks postoperatively Each dice is well-surrounded by cancellous bone, the matrix of which becomes continuous with the cartilage matrix. Chondrocytes stain well and are arranged in flattened "piles," as in a healthy epiphyseal line. Ossification is progressing from one side. Here, large empty lacunae communicate with the medullary cavity.

Six weeks postoperatively All dices are now firmly bound together by connective tissue and cancellous bone. There is continuity of bone and cartilage matrices. Invasion of the dices by large channels continues but these inroads are for the first time filled with clumps of deeply-staining round cells. These tend to line the channel walls.

Seven weeks postoperatively The remains of cartilage dices are seen as

FIG 5

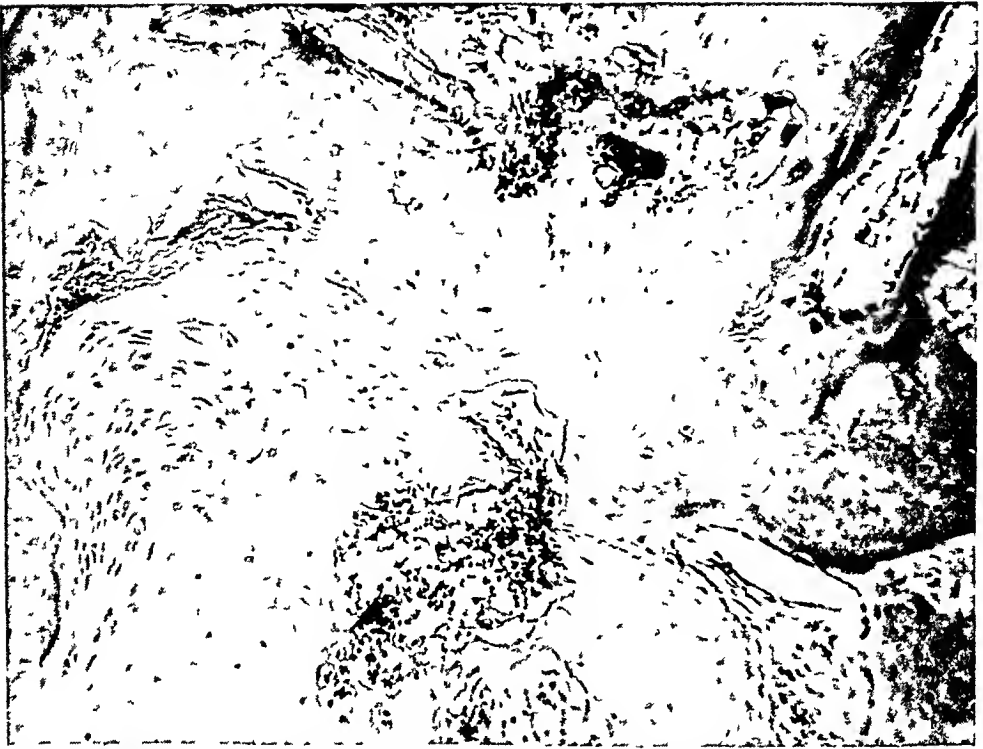


FIG 6

FIG 5—Six weeks postoperatively A portion of cartilage is firmly embedded in cancellous bone. Some lacunae are cystic and enlarged, while others contain many chondrocytes and some mitotic figures are seen in these latter. The matrices of surrounding bone and cartilage are continuous. The tongue of absorption contains many small deeply-stained round cells.

FIG 6—Seven weeks postoperatively A small island of cartilage completely buried in cancellous bone. Some lacunae contain deeply-stained chondrocytes.

HOMOGENOUS FETAL CARTILAGE GRAFTS

Fig 7

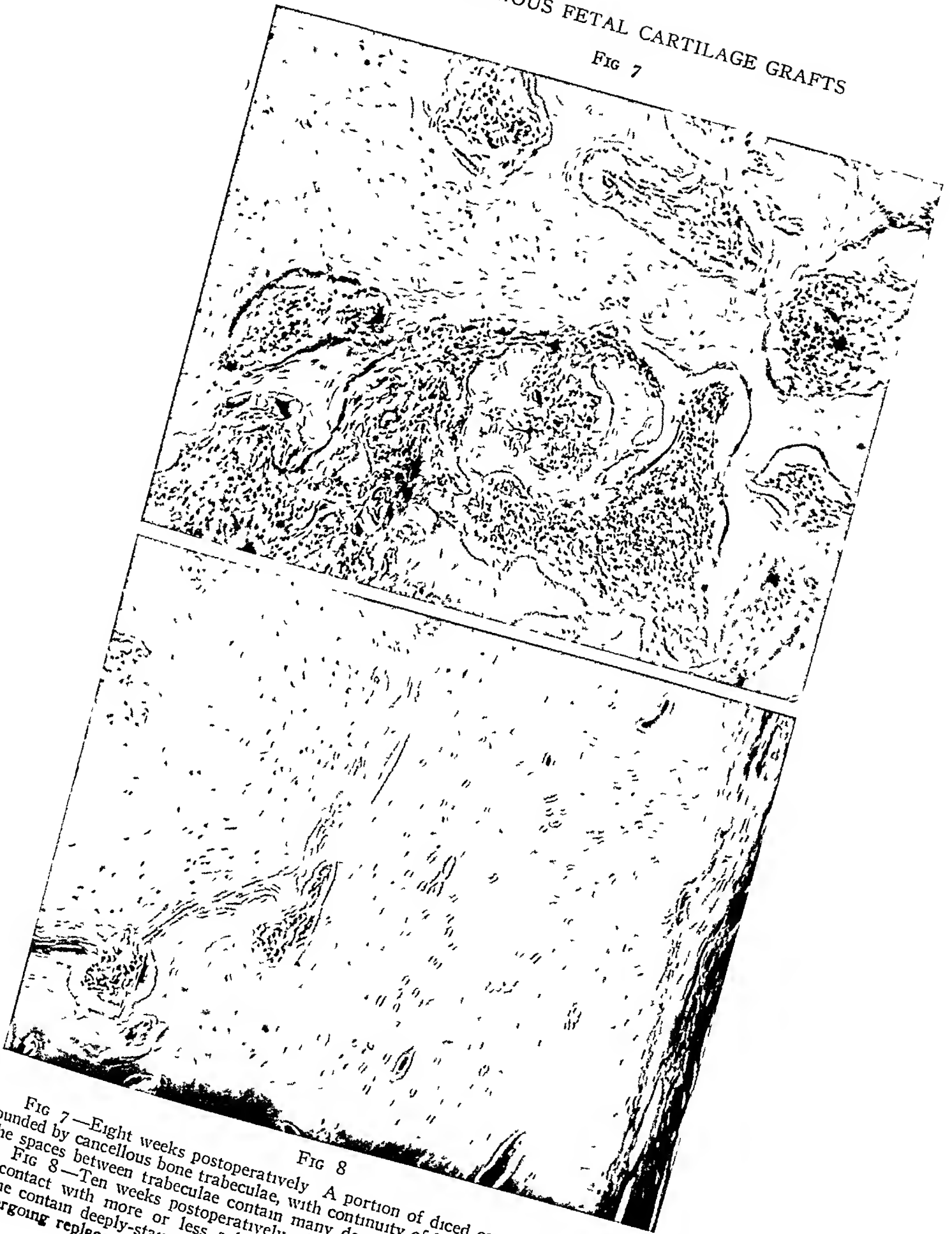


Fig 8

FIG 7—Eight weeks postoperatively. A portion of diced cartilage is seen surrounded by cancellous bone trabeculae, with continuity of bone and cartilage matrix. The spaces between trabeculae contain many deeply-staining round cells.

FIG 8—Ten weeks postoperatively. A small portion of fetal cartilage is seen in contact with more or less solid bone. The dice shows some empty lacunae. Some contain deeply-staining cells, but all lacunae are enlarged and appear to be undergoing replacement.

islands of cartilage more or less walled-off by cancellous bone. Many lacunae retain two or more cells, but these are larger and paler than formerly, and a few lacunae are empty. Round cells buried in meshwork line the walls of bony trabeculae.

Ten to 12 weeks postoperatively Islands of cartilage remain completely surrounded by thickened cancellous bone. Lacunae are enlarged and some in the central portions of the grafts are empty, cystic and tend to coalesce. Many, however, retain deeply-staining nuclei of chondrocytes, but all evidence of mitosis has disappeared. A few scattered tongues of erosion are seen between cartilage and bone. These contain many deeply stained cells but no giant cells.

DISCUSSION—If transplanted epiphyseal cartilage continued to grow at the rate of untransplanted cartilage, and if replacement by bone followed the normal pattern, one could expect bizarre exostoses to result from such grafts. That this is not the case is now evident. We must conclude that while homogenous grafts survive for the most part, propensity for growth is generally lost. Replacement by bone follows the scheme already established for autogenous cartilage grafts to bone.

When homogenous tissues are grafted, a reaction to the foreign material is observed. It is minimal in cartilage and corneal grafts. This takes the form of a lymphocytic reaction which reaches its peak around 30–50 days after transplanting and then falls off gradually (Loeb⁸). We believe the clumps of deeply-staining round cells seen first in the six-weeks specimen represents this lymphocytic reaction against fetal homogenous material. It is interesting to note that in fowl, which normally have a higher percentage of lymphocytes than mammals, this reaction reaches such proportions as to absorb homografts entirely (Loeb and Siebert⁹).

CONCLUSIONS

- 1 Fetal rabbit cartilage, when diced and grafted into a long bone of an adult animal will survive up to three months.
- 2 Slow replacement by cancellous bone from the host takes place, similar to the replacement of autogenous diced cartilage grafts.
- 3 No evidence, gross or microscopic, is found that fetal tissue after homografting retains any great propensity for growth or differentiation.
- 4 A mild localized round cell reaction is observed to reach its peak about six weeks after transplanting.

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ACROMIOCLAVICULAR DISLOCATION

END-RESULTS OF SCREW SUSPENSION TREATMENT

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AMONG the various operative methods for the repair of complete acromioclavicular dislocation which have been advocated are fascial suture,¹ - wire fixation,^{3, 4, 5} and excision of the tip of the clavicle^{6, 7} The proponents of each of these procedures have reported favorable results in their own hands

It is now six years since I introduced treatment by screw suspension⁸ In a little over a year, from December, 1940, to January, 1942, I performed this operation upon eight patients This is a report of the end-results of each of those operations Nine additional cases in which this method was used by other surgeons are included in the clinical protocol, although they are excluded from the summary of end-results, as none of them was ever seen by me personally

This operation was designed temporarily to maintain reduction of a complete acromioclavicular separation by the insertion of a single vitalium screw, under local anesthesia, through the outer portion of the clavicle into, and through, the underlying coracoid process of the scapula Subsequent to publication of my original paper the same operation was independently devised by Vere-Hoge in England It was used successfully there in the treatment of air casualties of the recent war⁹

In each of my cases the screw alone was depended upon for full support during the period of healing Although a sling was always prescribed post-operatively no patient wore it more than a few days because of the relief and feeling of well-being experienced as a result of the screw support

Seven of my cases were freshly incurred injuries but one of them became a three-month-old redislocation, with a frozen shoulder, before final and successful repair One other came to me as a two-month-old injury, with frozen shoulder The patients varied in age from 23 to 74 years and, in physique, from paratroopers to elderly ladies All were operated upon in the hospital, with full operating room facilities and assistance available They spent only one night in hospital (with the exception of the two cases of frozen shoulder which were kept longer for traction suspension following freeing of the adhesions about the shoulder joint) One patient went home the day of operation

In no case in which the newly designed flanged screw was inserted through both cortices of the coracoid process did it pull out, even partially, nor did the original fine-threaded screw pull out in three of the four patients in whom it was used In two cases the screw broke without pulling, with one failure in a man who refused reoperation and one success, with permanent reduction and full function The screw was removed from two of my

patients, at six and seven weeks, respectively, with no recurrence of dislocation in either one. No screw has ever migrated to another part of the body.¹⁰

Callus and bone, visible by roentgen ray, have developed within the substance of the coracoclavicular ligaments to some extent in every case. At times this has resulted in the formation of a considerable mass of bone but with no interference with function. Absorption of bone about the screw threads has occurred without affecting the end-result in any way, but it seems to be the exception rather than the rule when the screw is properly placed.

Six of my patients have now been followed, with personal examination, over four years, two of them more than five years, since operation. Another was last seen at two years and three months and another at six months. In six patients perfect reduction and function of the acromioclavicular joint have been preserved by the screw repair. One patient has perfect function and has been doing heavy work for three years although the screw pulled a quarter of an inch. Another completely redislocated after the screw broke at four weeks and the patient has refused further treatment.

If the results in these eight cases are considered with respect to anatomy (A), economics (E), and function (F), and are graded from 0 to 4 (0 denoting failure and 4 being excellent), they may be summarized as follows: Six cases—A4—E4—F4, one case—A3—E4—F4, one case—A0—E2—F2.

Details of the operative technic have already been published.⁸ The following modifications have been made as the result of added experience.

(1) *The Screw and Its Implantation*—Only a screw of an electrolytically inert material, having a wide-flanged thread of minimal pitch and a broad, flat head, should be used. In most patients the one and a half-inch screw will grip the under surface of the coracoid adequately with the acromioclavicular dislocation reduced. Occasionally, when the distance between coracoid and overlying clavicle, following reduction, is greater than normal (one-half inch) or the individual has very large bones, it may be necessary to employ the one and five-eighths or the one and three-quarter-inch screw.

Complete reduction must be secured before the hole in the clavicle is drilled and the screw inserted so that proper direction of the screw is assured. A tiny hole may be made with an awl in the upper surface of the coracoid to start the screw but the coracoid must not be drilled and the screw must penetrate both cortices of that bone.

Roentgenograms taken during operation have proven superior to fluoroscopy as a means of checking placement of the screw. It is more comfortable for the patient, and easier for the surgeon, if the patient is supine on the table rather than sitting in a chair during the operation. The clavicle depressor originally recommended⁸ has been found unnecessary.

(2) *Postoperative Care*—Although my patients have all regarded a sling as a nuisance, it is an excellent psychologic adjunct to treatment, for it serves as a constant reminder of their potential infirmity until soft-tissue support is attained. The sling should be removed at times during the day and the pa-

tient encouraged to do arm-swinging exercises and "crawling up the wall." He should also be allowed to bathe, dress and feed himself, to shave and to brush and comb his hair, all from the day after operation. In between these activities, and at night, a sling should be worn for the first eight weeks. Any heavy work during this period must be interdicted by the surgeon in no uncertain terms and he should see the patient frequently to make sure that these orders are obeyed. The screw may be left in place indefinitely or removed after eight weeks.

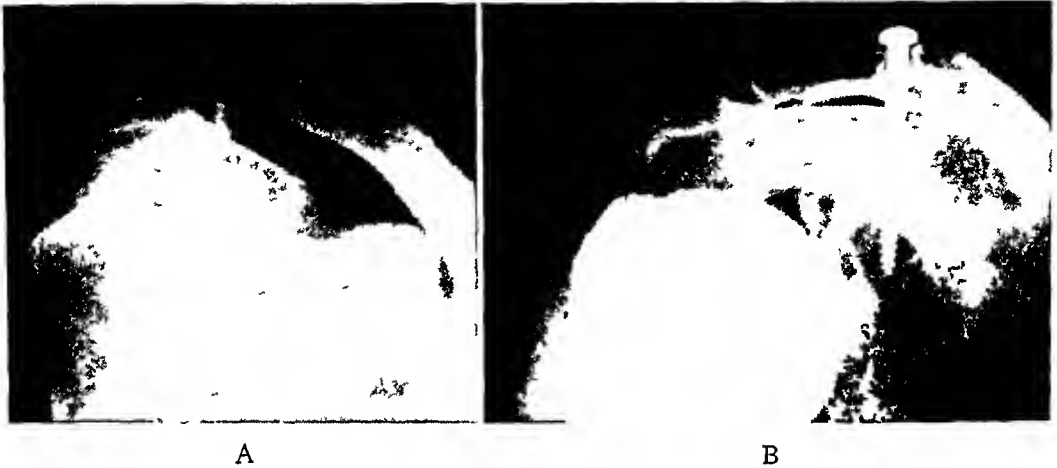


FIG 1—Case 1 P B, housewife, age 74

A Before operation

B Five years and 4 months result with old type screw A4—E4—F4

CLINICAL PROTOCOLS

Author's Cases

Case 1—P B, the first patient to undergo this method of repair was operated upon 12-14-1940, at age 74.⁸ She had sustained a complete right acromioclavicular dislocation from a fall three days before operation (Fig 1A). Severe generalized arthritis made immobilization of the upper extremity inadvisable. Personal examination over five years after operation reveals no gross deformity, no limitation of motion and no impairment of strength compared with the other shoulder. This in spite of the fact that two months after operation she fell downstairs again and pulled the screw about one-eighth inch as shown by roentgen-ray.

COMMENT In view of the fact that later roentgenograms (Fig 1B) showed absorption of bone about the screw it is obvious that permanent maintenance of reduction is dependent, as was anticipated, upon firm healing of the soft-parts and not upon the screw. The formation of bone between coracoid and clavicle is interesting. Five years and four months result A4—E4—F4.

Case 2—M B, was operated upon 2-7-41, at the age of 73,⁸ ten hours after she had fallen from a chair. The tip of the clavicle was displaced 1.5 inches above the acromion and nearly compounded the overlying skin (Fig 2A). An excellent reduction

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was secured, but at three weeks she did heavy housework, against advice, and redislocated. The same screw was replaced but failed to hold. Three months after the original operation this screw was removed and replaced, under direct vision, with a specially designed flange-threaded screw. At the same time adhesions which had formed about the shoulder



A

B

FIG 2—Case 2 M B, housewife, age 73

A Before operation

B Five years and 2 months result A4—E4—F4



FIG 3—Case 3 J M, laborer, age 65

Two years and 3 months result with old type screw which broke
Patient refused reoperation A0—E2—F2

joint were broken up by manipulation under general anesthesia. Clinically, the patient has no complaints referable to the injury or repair. She does all her own housework. There is no deformity, no loss of strength and she has full active motion in the affected shoulder.

COMMENT This case proves that screw suspension can be used successfully in an old persistent dislocation even in the presence of a frozen shoulder severe enough to require manipulation under anesthesia. The lack of bone absorption about the screw threads is noteworthy as is the production of new bone in the soft-tissues between coracoid and clavicle (Fig 2B). Note that the screw penetrated both cortices of the coracoid. Five years and two months result. A4—E4—F4

A



B



C

FIG 4—Case 5 E G laborer, age 27

A Before operation

B Screw not inserted deeply enough

C Four years and 10 months result A3—E4—F4 Excellent function although screw had pulled slightly

Case 3—J M, was operated upon 2-20-1941, at the age of 65. A fall on the ice two days previously had resulted in a complete right acromioclavicular dislocation. Full reduction was not secured at the time of operation. The old style screw was used and at four weeks it broke, with recurrence of dislocation (Fig 3). This patient persistently refused reoperation with the new type of screw. When last examined, two years and three months after operation, his only complaint was of occasional pain in the affected shoulder and weakness in the arm.

COMMENT Partial reduction placed the screw at a great mechanical disadvantage and subjected it to increased stress, yet, because the screw was inserted through both cortices of the coracoid it did not pull out—it broke. The result at two years and three months, must be classed as an operative failure, patient refusing further treatment. A0—E2—F2

Case 4—A M, was operated upon 2-20-1941, at the age of 34, for a complete left acromioclavicular dislocation^s. This was a compensation case involving a highly nervous, very apprehensive individual whose injury was the result of a fall the day before operation. Roentgenograms^s and clinical examination at seven weeks showed excellent reduction with complete, strong painless function. However, patient worried constantly about having a metal screw in her shoulder and it was removed by another surgeon. When patient was last seen by me, six months after the original operation, there were no complaints referable to the shoulder and she had been doing heavy work as a masseuse for three and a half months. There was no deformity, no limitation of motion, no weakness and no pain.

COMMENT The screw in this case was placed through both cortices of the coracoid and though it was of the old fine-threaded variety it held securely until it was removed. Six months result A4—E4—F4



FIG 5—Case 6 C P, athlete, age 24
A Screw not inserted deeply enough
B Four years and 6 months result. Note abundant callus. Served overseas as paratrooper. A4—E4—F4

Case 5—E G, was operated upon 4-23-1941, at age 27, for a complete left acromioclavicular dislocation (Fig 4A and B) resulting from a fall on the shoulder a day or two before. This patient resumed heavy work in less than four weeks, against advice. Recently, five years since operation, this patient writes from California: "I have been doing heavy work now for about three years. The screw is still where you put it. I hardly ever give it a thought any more as my left shoulder don't pain or bother me." Roentgenograms (Fig 4C), taken 2-5-1946, show slight pulling of the screw with new bone formed about the shaft and no absorption about the screw threads.

Case 6—C P, at the age of 24, suffered a complete left acromioclavicular dislocation when he was struck forcibly on the point of the shoulder by another man's head during a baseball game. Operation was performed, 8-22-1941, one week after injury, with the new flanged screw. In this case, also, the screw pulled slightly (Fig 5A). At six weeks the screw was removed, under local anesthesia. This patient was a big, heavily-muscled young man who was accepted for enlistment in the air corps within one year after operation. Later, he served as a paratrooper in the Pacific. Examination, 2-5-'46, revealed an apparently normal shoulder. There was no pain, limitation of motion, deformity or weakness. Roentgenograms (Fig 5B) show maintenance of good reduction, with a heavy mass of bone apparently uniting the coracoid to the overlying clavicle. On roentgenograms taken in other planes, however, a pseudarthrosis can be seen to traverse this bony mass horizontally.

COMMENT In both the preceding cases, the screw was not inserted far enough to grip both cortices of the coracoid and the patients resumed heavy work, against advice, too soon. Four years and ten months result in Case 5 A3—E4—F4. Four and one-half years result in Case 6 A4—E4—F4.

Case 7—R H, at the age of 23, sustained a complete right acromioclavicular dislocation (Fig 6A) by landing on the point of his shoulder while making a flying

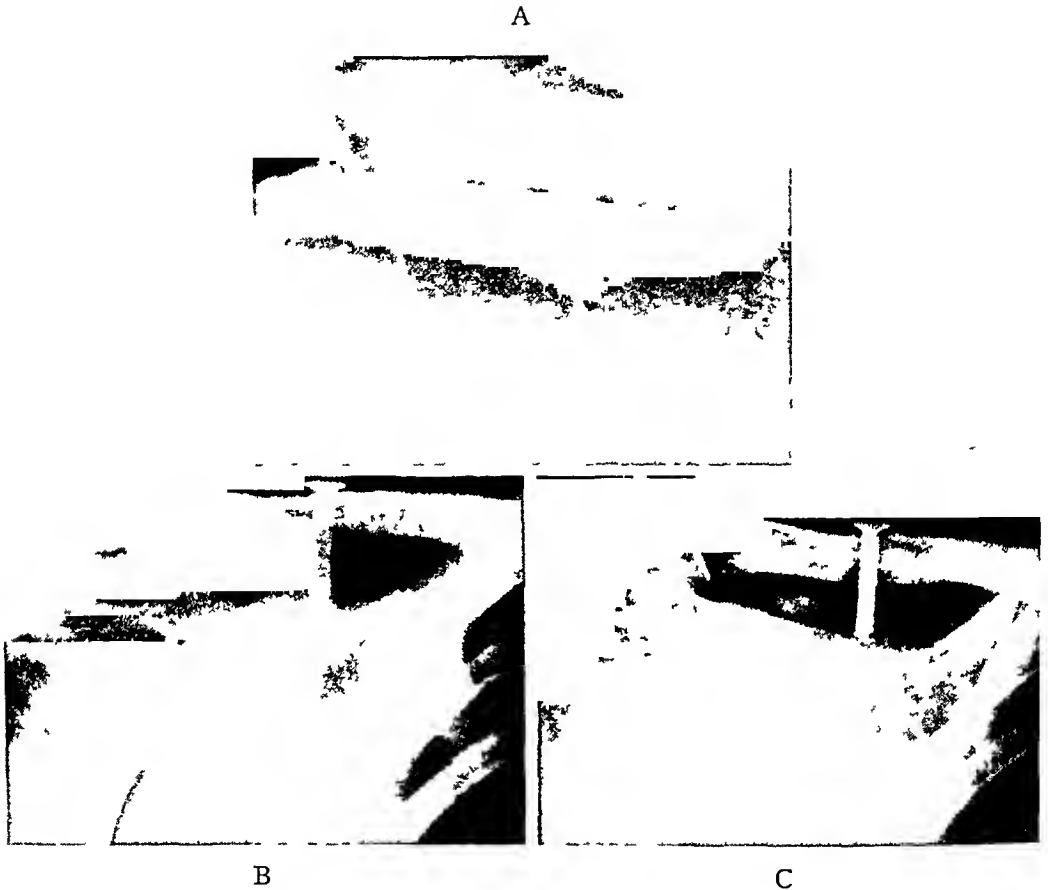


FIG 6—Case 7 R H, electrical engineer, age 23

- A Failure of pressure dressing
- B Screw reduction
- C Four years and 2 months result. Reduction maintained despite breaking of screw. Patient accepted by navy. A4—E4—F4

tackle in a football game. This was another tall, muscular individual. Tight adhesive strapping for two weeks failed to maintain reduction and caused extreme skin irritation. Operation was performed, 12-20-1941, with the new flanged screw. Excellent reduction was secured (Fig 6B), and he returned to full (clerical) work eight hours a day the second day after operation, without a sling. He dressed and took care of himself from the day of operation but he noticed a slight restriction of motion in reaching across his chest or behind his back. Ten weeks after operation, while lifting a 75-pound weight, he felt the screw snap and immediately found himself with a complete range of motion. In 1944, he was accepted for service in the navy. Examination, 2-22-1946,

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revealed no pain, tenderness, limitation of motion, weakness or deformity. Roentgenograms (Fig 6C) show the broken screw, but reduction well-maintained and considerable bony callus in the healed coracoclavicular ligaments.

COMMENT In this case the screw obviously interfered to a slight extent with full range of motion in the acromioclavicular joint until the screw broke. When, as here, the screw restricts motion, it should be removed at eight weeks. Four years and two months result. A4—E4—F4

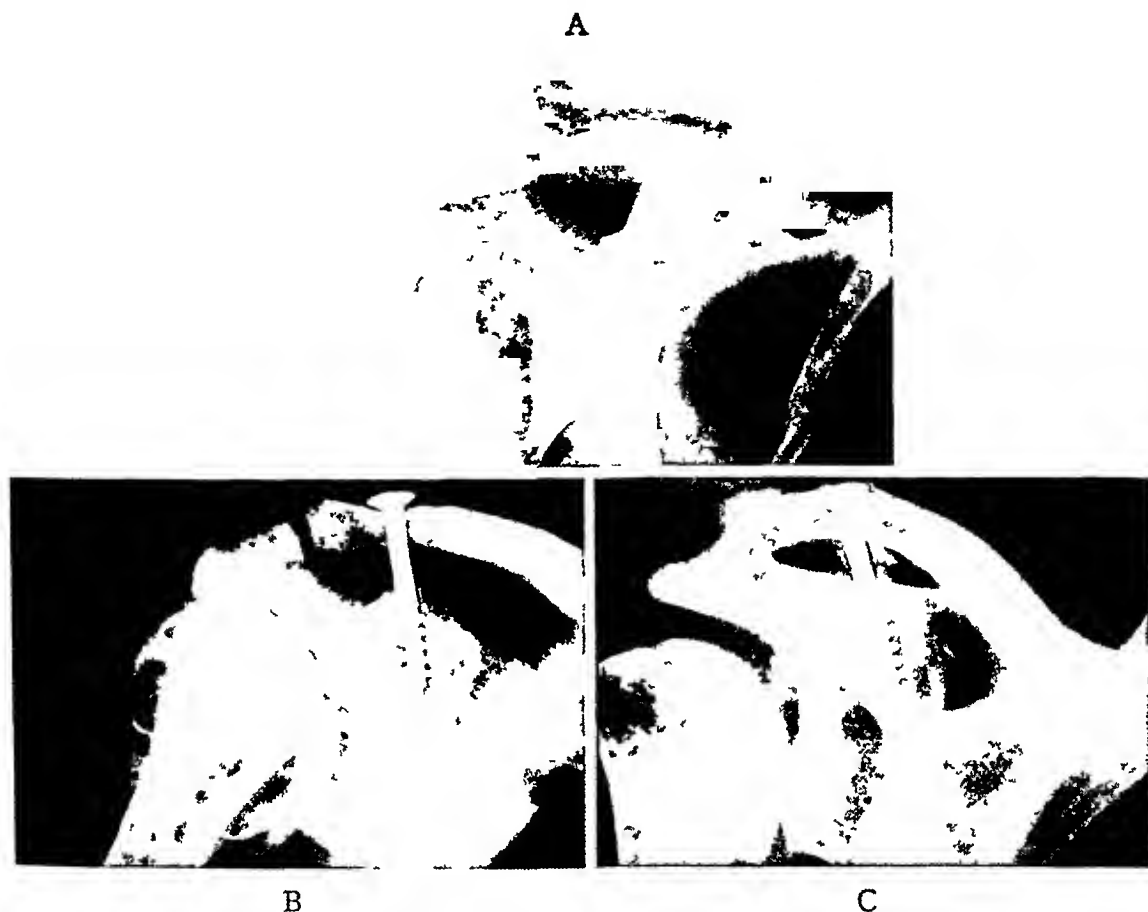


FIG 7—Case 8 N W, housewife and business woman, age 47

A. Firmly adherent acromioclavicular dislocation and frozen shoulder

B. Fracture of humerus following remanipulation by another surgeon seven weeks after original surgery. Note that screw did not pull in spite of force applied.

C. Four years and 2 months result. No recurrence of acromioclavicular dislocation. A4—E4—F4. Surprisingly good function with malformed head of humerus.

Case 8—N W, at the age of 47, was knocked down by an automobile more than two months before she came for treatment. During this time she had been wearing a pressure dressing and receiving physiotherapy three times a week. Examination revealed a very thin, extremely apprehensive woman who seemed on the verge of a nervous breakdown. There was a persistent severe dislocation of the right acromioclavicular joint, the tip of the clavicle riding above the acromion (Fig 7A). It had become fixed in this position by adhesions and could not be reduced. All motions in the shoulder joint were severely limited by adhesions and attempts at passive motion elicited intolerable pain. At operation, 1-13-1942, the adhesions about the frozen shoulder joint were broken up by manipulation under general anesthesia. The acromioclavicular joint was exposed, adhesions severed by sharp dissection and complete reduction was secured. This was

maintained by the insertion of a flanged vitalium screw in the usual manner. One week after operation I was called to active army duty and lost control of the patient. Seven weeks after the initial surgery, manipulation under anesthesia was again performed by another surgeon to free the shoulder joint which had refrozen. This, unfortunately, resulted in a fracture through the rarefied surgical neck of the humerus (Fig 7B) although reduction of the acromioclavicular dislocation was maintained by the screw. The patient was discharged three weeks later, but for eight months she returned to

A



B



C

FIG 8—Case 9 M C, laborer, age (?) (Courtesy of Dr D H Maunz, Bradford, Pa.)

A Preoperative film

B Screw inserted well through both cortices of coracoid

C Five months result. Note maintenance of reduction despite heavy work and extensive callus formation in coracoclavicular ligaments. A4—E4—F4

the clinic daily for physiotherapy. When seen four years and two months after operation, this woman had changed from a pain-ridden cripple to a cheerful housewife. The acromioclavicular joint remained reduced, but there was restriction of motion in the shoulder joint due to the fracture of the humerus previously mentioned. She could reach

well behind her back, to the back of her neck and the top of her head. Roentgenograms (Fig 7C) show reduction of the acromioclavicular joint with the screw encapsulated by bone. The humeral fracture has healed, with a deformed head.

COMMENT This case was an old acromioclavicular separation complicated by a badly frozen shoulder and a subsequent fracture of the surgical neck of the humerus incurred during treatment. Four years and two months result of the acromioclavicular repair. A4—E4—F4

Cases of Other Surgeons (based on personal communication)

Case 9—(From Dr. Daniel H. Maunz, Bradford, Pa.) M. C., a manual laborer, 12-14-1941, suffered a complete acromioclavicular dislocation (Fig 8A). An attempt to insert the screw in the coracoid, 1-2-1942, with patient sitting upright, failed. On 1-6-1942, with patient lying on his back and under general anesthesia, open reduction of the acromioclavicular separation was accomplished, the coracoid was exposed and the

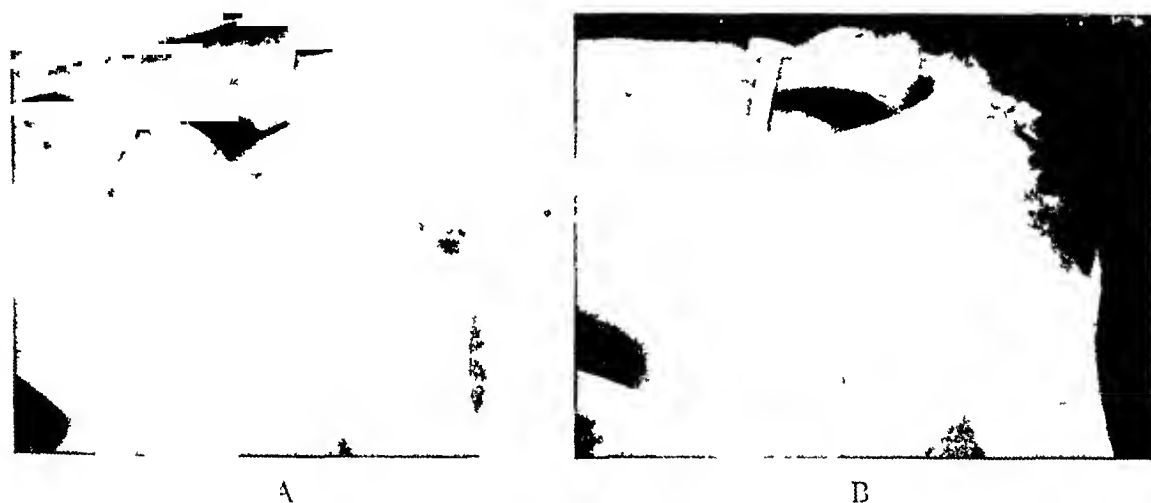


Fig 9—Case 10. N. B., laborer, age 47 (Courtesy of Dr. G. K. Coonse, Boston, Mass.)

A. Four months old acromioclavicular dislocation.

B. Six months result. Dislocation over-reduced. A4—E4—F4

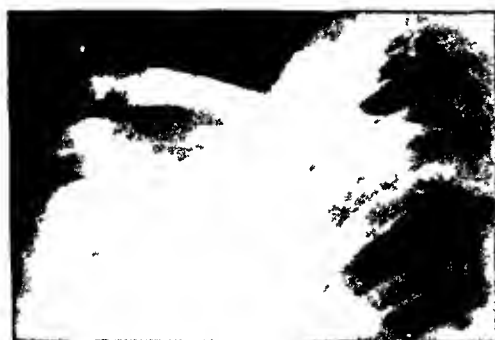
screw inserted under direct vision (Fig 8B). Latest roentgenograms (Fig 8C), taken more than three months after operation, show maintenance of excellent reduction, no absorption about the screw threads and a mass of fresh callus extending from coracoid to overlying clavicle. When last seen by Doctor Maunz in June, 1942, five months after operation, the patient was doing heavy work and had no complaints. This patient died of other causes some two years ago.

COMMENT Note that the screw penetrated both cortices of the coracoid and that abundant callus formed in the region of the torn ligaments. Five months result. A4—E4—F4

Case 10—(From Dr. G. Kenneth Coonse, Boston, Mass.) N. B., a manual laborer, presented an acromioclavicular dislocation that was more than four months old (Fig 9A). Screw reduction was performed in April, 1941, and the patient returned to fairly heavy labor two months later. At the last examination six months after operation Doctor Coonse reported "a very satisfactory end result. At present time there is less prominence on the affected side than on the normal side." Roentgenograms (Fig 9B) taken one month postoperative show reduction maintained by screw in good position.

COMMENT This was an old persistent acromioclavicular separation successfully treated with screw suspension. Note again that the screw was made to penetrate both cortices of the coracoid, and that callus formed in the ligaments. Six months result A4—E4—F4

Case 11—(From Dr F W Slobe, Chicago, Ill) "H H, age 59, was injured 10-1-1945, the outer end of the clavicle projecting into the muscles and skin posteriorly (Fig 10A). He was operated upon 10-4-1945. Recovery was uneventful, and he was singularly free from pain and discomfort during convalescence. He returned to his work as a teamster six weeks later. Roentgenograms (Fig 10B) taken in December, 1945 show some upward displacement, with the screw pulled out partially." Five months after operation "there has been no increase in the deformity as indicated on his last roentgenograms. He has very little discomfort in the shoulder and has full range of motion."



A



B

FIG 10—Case 11 H H, teamster, age 59 (Courtesy of Dr F W Slobe, Chicago, Ill)

A Complete acromioclavicular dislocation

B Five months result. Screw not inserted deeply enough. Excellent function. A3—E4—F4

COMMENT This was an industrial case and he has made no claim for compensation which, I think, is quite indicative of how he feels about the result. I feel also that functional impairment is minimal.

Case 12—(From Dr F W Slobe, Chicago, Ill) "A S, age 43, 1-22-1946, was injured in an automobile accident and suffered a complete acromioclavicular dislocation on the right side. We did not see the patient until a few days later, when he was sent to the hospital and was operated upon. It appeared that we had a good fixation and reduction in the operating room, but roentgenograms taken the following day showed that the screw had only contacted part of the coracoid (Fig 11A), so a few days later the procedure was performed again, this time being checked by an anteroposterior roentgenogram. This worked very well and we obtained an excellent reduction (Fig 11B)."

COMMENT These two cases illustrate the superiority of roentgenograms over fluoroscopy as a means of checking screw position during operation, as well as the necessity of sinking the screw firmly into the coracoid so that its threads grasp the under cortex of that bone. Five months result in Case 11 A3—E4—F4. It is too early to give an end-result in Case 12.

Case 13.—(From Dr W F Cotting, Boston, Mass) "A young man fell off a traveling crane, and I was able to insert one of your screws and obtain a very excellent result He was immobilized in a double sling for about two weeks, and within four weeks had normal motion It is now 12 weeks since he was injured, and he shows today perfectly normal shoulder motion with no loss of function" Neither the roentgenograms nor the patient can be located

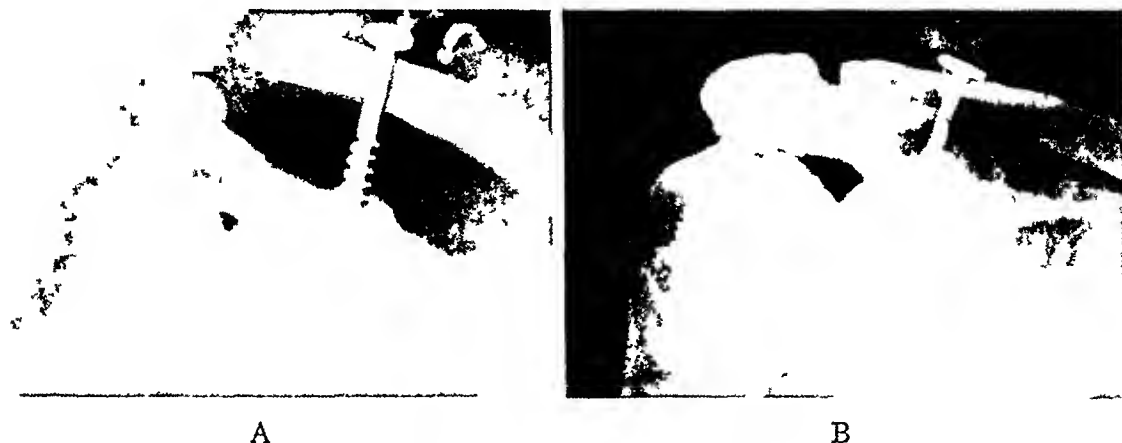


FIG 11—Case 12 A S, occupation (?), age 43 (Courtesy of Dr F W Slobe, Chicago, Ill)

A First attempt at reduction using fluoroscope Screw not inserted deeply enough
B Reoperation, using roentgenologic check-up Screw solidly implanted Case too recent for end-result



FIG 12—Case 17 (Courtesy of Dr S A Bernstein, Brooklyn, N Y) Four-year result A4—E4—F4

Case 14.—(From Dr W F Cotting, Boston, Mass) "I operated upon G M, 10-25-1941 He was a truckdriver and made a good recovery He had normal range of motion in the shoulder and no appreciable mobility at the acromioclavicular joint He made his last postoperative visit on 11-17-1941 I heard no more from him until 3-9-1942 Examination then showed a foreign-body reaction manifested by some local tenderness and inflammation On 3-16-1942 (five months after the original operation) I

removed the screw under local anesthesia, and last saw him postoperatively on 4-6-1942. He was back at work and had no symptoms. The wound was fully healed and he had normal motion and function. I have been unable to locate the roentgenograms."

COMMENT Removal of the screw in Case 14 apparently did not weaken the repair. Although roentgenograms in both the foregoing cases can not be located, reliable clinical examination indicates the end-results at three months in Case 13 and five and one-half months in Case 14 as A4—E4—F4.

Cases 15 and 16 —(From L. E. Gilje, Capt., M. C., U. S. N., Chief of Surgery, U. S. Naval Hospital, Bethesda, Md.) "I used the acromioclavicular screw on two cases. In the first case, the screw broke loose from the coracoid process after about six to eight weeks and had to be removed because it was producing pressure on the surrounding area. In the second case, the screw was utilized to fix the distal end of the clavicle to the coracoid process and a portion of the short head of the biceps was brought up and anchored to the clavicle. The screw was only left in place until the tendon of the short head of the biceps was firmly adherent to the clavicle."

COMMENT It is regrettable that the roentgenograms in these two cases are unavailable. Also, there is no indication as to when these two patients resumed heavy work. However, the end-result in the first case was an obvious failure and that in the second case, although apparently successful, is immaterial since the screw was used as an adjunct in the operation and not depended on for sole support.

Case 17 —(From Dr. S. A. Bernstein, Brooklyn, N. Y.) "I operated upon my patient 4-6-1942. He had a full range of motion four weeks after the operation. Examination 3-22-1946. Patient states that the right shoulder does not bother him except for a slight grating noise on certain motions of this joint. He uses the arm very freely and does not spare it. He was discharged from the army after two and one-half years of service in an engineer outfit. His discharge was not predicated on any disability. The right shoulder shows no elevation of the outer end of the clavicle as compared with the left. There is a full range of active motion in all directions. No weakness of the muscles of the right shoulder girdle. Good power of both hands. There is no tenderness over the outer end of the clavicle." Roentgenograms (Fig. 12) show that the screw has not moved, and that reduction of the acromioclavicular joint has been maintained.

COMMENT Two and one-half years of service in an engineer outfit during the recent war is a good test of any method used in repairing an acromioclavicular dislocation. Four-year end-result A4—E4—F4.

SUMMARY

Detailed end-results have been presented of 17 cases in which a suspension screw was used by seven different surgeons in the treatment of acromioclavicular dislocation. Eight of these are the first consecutive cases in which the operation was used. Modifications of the operative technic are presented.

CONCLUSIONS

The long-term end-results of screw suspension in the treatment of acute and chronic dislocation of the acromioclavicular joint have been very satisfactory. In addition, disability of the patient has been minimized, early

mobilization of the extremity has been assured, and convalescence shortened. Experience has shown that dangers inherent in the operation are negligible.

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ISCHEMIC NECROSIS OF THE ANTERIOR CRURAL MUSCLES

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ISOLATED NONINFECTIVE GANGRENE involving the muscles of the anterior compartment of the lower leg is not a frequently encountered clinical entity. In 1942, Child¹ reported such a case following a simple fracture through the middle third of the tibia and fibula, and in reviewing the literature from 1850 to 1942, he could find only 14 cases of noninfective gangrene accompanying fractures of the lower leg, only one of which involved the anterior tibial artery alone.

With the advent of large orthopedic services in Army hospitals throughout the country, this condition of localized gangrene has been recognized more frequently. The failure to recognize and diagnose accurately the condition no doubt accounts for the small number of cases reported in the literature. Sirbu, Murphy and White² have reported four cases of ischemic necrosis of the anterior crural muscles. Two of these cases were associated with fractures of the lower leg, another case followed surgical repair of a defect in the anterior crural fascia, and the fourth case had no antecedent trauma other than participation in a long march. Recently, Horn³ has reported two similar cases not associated with any acute trauma.

The etiology of this condition, of course, is a functional impairment of the anterior tibial vessels of a degree sufficient to produce gangrene of the anterior crural muscles. In the cases which are associated with fracture of the tibia or fibula, it seems logical to assume that the anterior tibial vessels may have been damaged irreparably at the time of the original injury, even though the fracture may show little comminution or displacement and the trauma producing the fracture may have been of a minor character.

Anatomically, there are several factors which may enhance the possibility of damage to the anterior tibial vessels in cases of trauma to the leg. The origins of the anterior and posterior tibial arteries are quite rigidly fixed by surrounding structures so that they are subject to injury not only by direct violence but also by force transmitted to the bifurcation of the popliteal artery from other parts of the leg. The anterior tibial artery passes to the front of the leg through a relatively small aperture above the upper border of the interosseous membrane. It is reasonable to assume that the vessel might be damaged by any trauma transmitted to this site. At this location, too, the vessel lies close to the medial side of the neck of the fibula, and might be traumatized easily by a jagged fragment of bone when the head and neck of the

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fibula are fractured. Finally, the boundaries of the anterior crural compartment are quite rigid structures, the thick deep fascia of the leg, the anterior intermuscular septum, the interosseous membrane, and the tibia and fibula rigidly enclose the tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius muscles. The anterior tibial vessels and the peroneal nerve enter this compartment and may be secondarily damaged by pressure produced by swelling within this tightly enclosed space.

In the absence of any acute trauma to the lower leg, the cause of the circulatory impairment of the anterior tibial vessels may be very difficult to determine. In one of the cases reported by Horn, a fibrosis of the media, adventitia, and periarterial tissue of the anterior tibial artery was found, and it was assumed that this fibrosis might be the result of repeated overwhelming demands made upon this vessel. Excessive walking and marching may have some direct relationship to circulatory disturbances in the anterior crural muscles.

The clinical aspects of this syndrome are well illustrated in the following case reports.

Case 1—After returning from a night cross-country training flight on 25 October 1943, a 25-year-old Air Cadet noticed a gradual onset of severe cramp-like pain in his left lower leg as he walked the half mile distance back to his base. The muscles over the anterolateral aspect of the left lower leg became hard and painful to touch, but there was no redness or swelling. He entered a local station hospital the same night where a diagnosis of acute osteomyelitis was made, despite the fact he had no fever. Warm stupes were applied to the entire left leg. The following day, 26 October 1943, the patient was operated upon. A four-inch longitudinal incision was made over the anterolateral aspect of the proximal third of the tibia and eight drill holes were placed in the bone. No pus was encountered at time of operation. The wound was packed open with vaselined gauze. On 15 November 1943, an attempt was made to close this wound by secondary suture, but the wound failed to heal.

The soldier was admitted to this general hospital on 31 December 1943 for further treatment. On admission the soldier was afebrile. There was a small draining sinus over the anterolateral aspect of the proximal third of the left tibia and a slightly tender fluctuant area over the lateral aspect of the distal third of the tibia. There was complete paralysis of all the anterior crural muscles. Roentgenograms of the leg revealed slight periosteal reaction involving the distal third of the tibia.

On 5 January 1944 the soldier was taken to the operating room, where both the fluctuant area and the draining wound were explored. Necrotic muscle and tendon were found in both areas. The two small incisions were connected by a longitudinal incision extending from the level of the tibial tuberosity to the level of the external malleolus. The anterior crural fascia was incised, exposing the soft, friable, reddish-gray muscle bellies of the anterior crural muscles. All of these muscles were necrotic and were removed readily by finger dissection. The anterior tibial vessels were ligated, but it was noted that there was very little bleeding in these vessels. There was no palpable pulsation in the anterior tibial artery, and the lumen of the artery was almost completely obliterated. The large cavity remaining after complete removal of the anterior crural muscles was packed loosely with vaselined gauze, and the skin edges were kept from retracting by four mattress sutures of heavy silk, tied over bolsters. A long leg plaster encasement was applied.

The postoperative course was satisfactory. The temperature was elevated up to 100° F for two days, and then the patient remained afebrile. The wound granulated in

rapidly, and there was never any evidence of true osteomyelitis of the tibia or fibula. Slight drainage continued from the scarred area, however, until 15 August 1943 (Fig 1A). On this date the major portion of the scarred area was excised, and the adjacent skin edges undermined and approximated. Healing was prompt and complete following this surgery.

The patient was ambulatory at this time, wearing a spring-toe brace to provide extension of his foot. To enable the patient eventually to discard this brace, the posterior tibial tendon was transplanted on to the dorsum of the left foot on 10 November 1944. Three months later, he was able to walk well without his brace. The tendon transplant functioned quite satisfactorily, permitting about 25° of active motion in the ankle joint and enabling the soldier to extend his foot to a right angle (Fig 1B).



FIG 1A



FIG 1B

FIG 1—Case 1 (A) Lateral view of lower leg, six months following excision of all the anterior crural muscles because of acute ischemic necrosis.

(B) Double exposure of same leg to show range of active motion in ankle ten weeks following transplantation of the posterior tibial tendon onto the dorsum of the foot. The depressed scar seen in (A) has been excised.

Case 2—A 33-year-old male, working in the Army for the American Red Cross, sustained compound comminuted fractures of both lower legs on 13 March 1943. He was struck by a hit-and-run civilian driver and thrown against the rear bumper of his own car. He was admitted at once to the station hospital of a local Army Air Base. There was a compound comminuted fracture through the middle third of the right tibia and fibula, with only a small puncture wound leading down to the fracture site. This fracture was treated by closed reduction and application of a long leg encasement. On the left, there was a severely comminuted fracture through the proximal third of the tibia and fibula, with loss of skin over the anterior aspect of the leg from a point two inches above the ankle to within four inches of the knee, exposing a portion of the crest and anteromedial surface of the tibia.

At the station hospital, the extensive wound of the left leg was debrided, the fracture of the tibia was reduced, and two of the small comminuted tibial fragments were

held in alignment with a single loop of stainless steel wire. A large pedicle of skin was elevated from the lateral side of the leg and swung across the anterior aspect of the leg in an attempt to cover the exposed tibia. The entire denuded area was covered with vaselined gauze, and a long leg encasement applied.

On 22 March 1943, the patient was admitted to this general hospital for further care. On admission, the patient's general condition was excellent, and there was no elevation of temperature. Both long leg encasements were badly blood-stained, and the left leg encasement was somewhat softened by drainage and very malodorous.

(In order to make the clinical course more clear, this discussion will be limited to the treatment of the left leg. It is of interest, however, to note that the fracture of the right tibia did not unite, and a bone-grafting operation was performed six months after the injury to obtain a solid bony union. At the present time there is no disability referable to the right leg.)

Soon after admission to the hospital, the encasement on the left leg was bivalved and the wound inspected. There was found a large granulating wound occupying the major portion of the anterior aspect of the lower leg, covered in part by necrotic skin. The pedicle of skin which had been elevated from the lateral aspect of the leg was completely gangrenous. There was a moderate amount of purulent drainage. The crest and anteromedial surface of the tibia was exposed in the distal two-thirds of the bone and the fracture site, as well as the loop of wire, were also exposed. There was a deep ulceration over the dorsum of the foot, measuring approximately two inches in diameter and covered with necrotic skin. There was complete paralysis of all the extensor muscles of the foot and ankle. The necrotic skin and the wire loop were removed. A posterior splint was fashioned to permit adequate dressing of the wound and azochloramid (N-N'-dichloroazodicarbonamidine) dressings were applied.

Guillotine amputation of the left leg was recommended, but this amputation was not considered an emergency procedure since there was no evidence of any detrimental systemic effect arising from the well-localized infective process in the leg. It was felt that amputation might be delayed until the outcome of the fracture of the right lower leg appeared more certain. Furthermore, it was believed that a delay in amputation might permit eventual salvage of a stump below the knee. The patient himself was very anxious not to have the left leg amputated.

The wound was treated with daily dressings of azochloramid. Since it soon became obvious that all of the anterior crural muscles had undergone ischemic necrosis, on 12 April 1943 all of these muscles were removed, exposing the entire anteromedial and lateral aspects of the tibia. The patient remained afebrile following this procedure, nor did he ever manifest even so much as a degree of fever following any of the subsequent operations on the left leg.

By 8 June 1943, the wound was clean and covered with healthy granulation tissue. The distal two-thirds of the tibia was still exposed, and it was evident that this exposed bone could not be salvaged. Consequently, this portion of the tibia was removed, leaving only the posterior cortex of the bone (Fig 2A). Seventy-five small pinch-grafts were applied to the granulating area on the lateral aspect of the leg. All of the exposed bone was now on a level with the granulation tissue, permitting granulations to grow over the bone.

On 9 July 1943, the entire wound, including the exposed tibia, was covered with thin scar, and there was no longer any drainage. The thin scar was excised and replaced by a split-thickness skin graft over an area measuring nine and one-half inches by four inches. There was a 100 per cent "take" of this skin graft (Fig 2C and D).

By 3 August 1943, the fracture of the tibia was well united, but further immobilization in a long leg encasement with a walking iron was carried out. This encasement was replaced by a long leg caliper brace on 8 December 1943.

The lateral edge of the tibia for a distance of about three inches in its middle third became exposed, and there was slight drainage from this region. On 4 February 1944

a portion of this exposed edge of bone was removed, and multiple drill holes were placed through this area to permit granulation tissue to grow up and cover the bone. By 14 March 1944, the bone was completely covered with epithelium again, and there was no drainage. The fracture of the tibia was solidly united, and there was a range of motion in the knee of from 180° extension to 90° flexion. On 13 July 1944, a small sequestrum was removed from the lower third of the tibia and this small sinus tract promptly healed.



FIG 2A

FIG 2B

FIG 2—Case 2 (A) Lateral and anteroposterior roentgenograms of the left leg three and one-half months after injury. The portion of the tibial shaft which was not covered by skin or granulation tissue has been removed, leaving only the posterior cortex of this bone in the middle and lower thirds.

(B) Lateral and anteroposterior roentgenograms of the left leg two years after injury. There has been considerable hypertrophy of the segment of posterior tibial cortex in the middle and lower thirds, and this portion of the bone has been the site of an old chronic osteomyelitis.

The patient was discharged from the hospital on 22 September 1944, wearing a short caliper brace on the left leg to guard against fracture (Fig 2C). There was 10° of active and passive plantar flexion at the ankle and 10° of passive dorsiflexion, there was no active extension of the foot. The ankle joint was not painful with walking.

A recent letter from this patient (dated 6 April 1946) states that the left leg has never hampered his activities as director of a Veterans' Information Center. He is able to walk as much or as far as he wishes, he drives his own car, and he finds dancing a pleasant pastime. He still wears the short leg caliper brace, but he feels that the brace

ISCHEMIC NECROSIS OF MUSCLES

causes him much less trouble than would an artificial leg. He does not wear the brace all the time while at home. From 21 May to 6 July 1945, a large pedicle flap along the medial surface of the calf was elevated and transferred in three stages to replace the skin graft over the left tibia. This flap healed well and now provides a better covering for the tibia.

Case 3—A 21-year-old Army sergeant was wounded in action by enemy mortar shell fire in Italy on 15 April 1945. He sustained multiple lacerations of the right lower extremity and a small "chip" fracture of the anterior aspect of the distal end of the tibia. His wounds were débrided and a plaster encasement applied in an evacuation hospital. On 18 April 1945, he was admitted to a general hospital in Italy. At this hospital it was noted that he was unable to actively extend his foot, and there was hypesthesia over the lateral aspect of the foot. An attempt was made to close all the wounds by secondary suture. All of the wounds healed except one on the anterolateral aspect of the middle third of the lower leg, and there was considerable purulent drainage from this area.

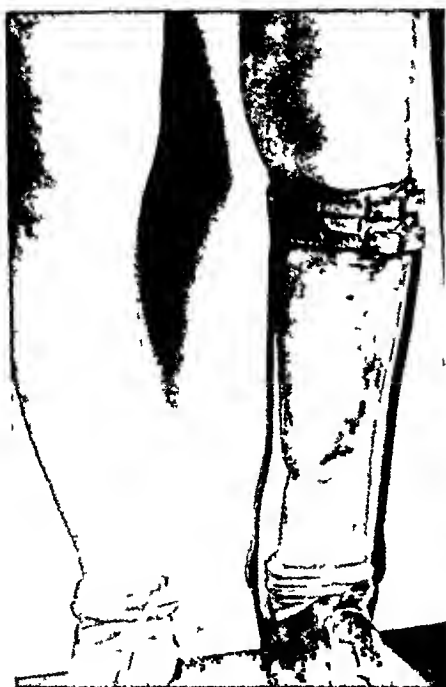


FIG 2C



FIG 2D

FIG 2—(C) Front view of both legs one year and six months after injury, showing the type of short caliper brace worn to protect the left tibia against fracture.

(D) Side view of the left leg one year and six months after injury. Note the extensive loss of both soft-tissues and bone in the distal two-thirds of the leg. The large defect has been covered by a split-thickness graft. One year later, this graft was removed and replaced by a pedicle flap.

On 27 May 1945, this unhealed wound was explored, and the muscle in the depths of the wound was found to be necrotic. The wound was extended by an incision the length of the anterior crural compartment. All of the anterior crural muscles were found to be necrotic, and all of these muscles were removed. The wound was packed open with vaselined gauze, and a plaster encasement applied.

On 28 September 1945, the soldier was admitted to this general hospital on the neurosurgical service for further treatment of his peroneal palsy. On examination, it was obvious that no neurosurgery was indicated. The peroneal muscles were functioning, but all the muscles in the anterior crural compartment were replaced by a depressed scar extending almost the entire length of the lower leg (Fig 3A and B).

Because of the presence of several small excoriations over the lower leg, surgery was delayed until 14 November 1945. On this date, the tendons of the tibialis posticus and peroneus longus muscles were transplanted on to the dorsum of the foot. By 26 February 1946, the patient was able to use the transplanted tendons quite well and could walk without a brace. He was discharged from the Army on a certificate of disability.

DISCUSSION—These three cases illustrate the clinical course of an ischemic necrosis of the anterior crural muscles. In Case 1 there was no obvious pre-

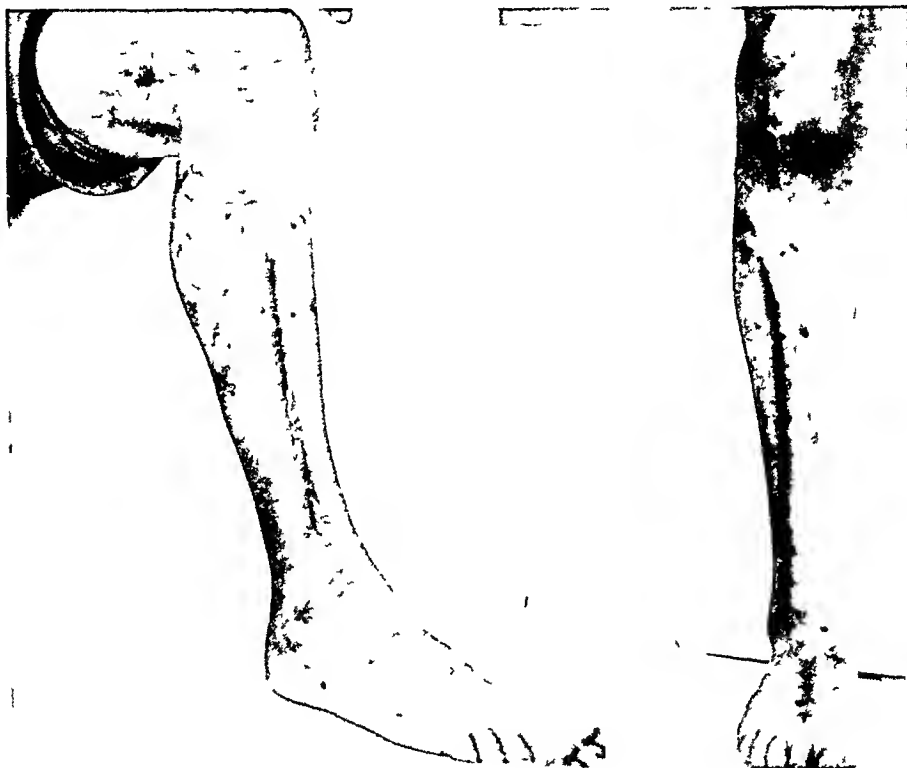


FIG 3A

FIG 3B

FIG 3—Case 3. (A) Side view, and (B) front view, of the right leg, six months after injury, showing the depressed scar which remains after surgical removal of all the muscles in the anterior crural compartment. There are multiple smaller scars over the entire leg which are the result of superficial lacerations by shrapnel fragments. Active extension was restored to the foot by transplantation of the posterior tibial and long peroneal tendons.

cipitating trauma, and there was no evidence of any peripheral vascular disease elsewhere in the patient. It cannot be denied that an embolus may have caused the rather sudden obliteration of the anterior tibial artery, but this is difficult to believe in the absence of clinical evidence of any abnormality in the cardiovascular system. Unfortunately no microscopic examination was made of the anterior tibial vessels themselves, although the gross appearance of the vessels at time of operation closely resembled the description given by Horn in one of his cases. Pathologic examination of tissue removed at the time of

operation in all three cases revealed the same picture of necrosis of skeletal muscle with fragmentation and dissolution of individual muscle fibers. No cause for the necrosis was apparent from a microscopic examination of the muscle tissue removed. It appears obvious, of course, that a traumatic thrombosis of the anterior tibial artery produced the ischemic necrosis found in Cases 2 and 3.

In Case 2, the correct diagnosis soon became obvious because of the extensive loss of skin overlying the anterior crural compartment. The correct diagnosis in the other two cases, however, was not made until the anterior crural muscles were explored surgically; in Case 1 this was two months after onset of symptoms, and in Case 3 it was one month after injury. A more prompt recognition of the condition with the institution of measures directed toward restoration or improvement of local circulation in the lower leg might prevent, or at least reduce, the extensive gangrene of muscle tissue. Lumbar sympathetic blocks are valuable in almost any case of arterial spasm. If these are not successful, surgical exploration of the anterior tibial vessel should be considered, with either periarterial sympathectomy or arteriectomy being done to improve the collateral circulation. Extensive fasciotomy of the anterior crural fascia might be assumed to relieve the increased pressure within the closed compartment.

If any surgical procedure is performed on a case of this type, extreme care must be taken not to introduce any pyogenic organisms, since once such organisms have been inoculated into a bed of necrotic muscle (as was done in Case 1), the infection cannot be controlled until all the necrotic tissue has been removed.

After the anterior crural muscles have been damaged irreparably, tendon transplantation, as illustrated in Cases 1 and 3, may restore adequate extension to the foot and enable the patient to walk without a brace. Either the posterior tibial muscle alone, or preferably this muscle in combination with one of the peroneal muscles, may be used. Arthrodesis of the ankle joint, or even arthrodesis of the subastragalar joint, should not be necessary in a case of this type.

SUMMARY

1 Localized ischemic necrosis of the anterior crural muscles is an infrequent complication of injuries to the lower leg.

2 Three cases of localized ischemic necrosis of the anterior tibial muscles are presented. Two of these were secondary to traumatic occlusion of the anterior tibial vessels, but the etiology in the third case could not be determined.

3 If this condition is diagnosed promptly, measures may be instituted to prevent complete devitalization of all the muscles in the anterior crural compartment.

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OBSTRUCTIVE LESIONS OF THE SMALL INTESTINE AND SIGMOID DUE TO IRRADIATION

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THE INTENT OF THIS REPORT is to emphasize to those not closely associated with a Department of Radiology, the late clinical picture of obstruction due to irradiation* This group of five cases being reported received irradiation for carcinoma of the corpus, cervix and ovary, and, who later, showed symptoms of obstruction

The complaints of those patients who develop lesions in the low sigmoid and rectosigmoid after irradiation are Abdominal cramp-like pains, associated with frequent small liquid stools, mucus and blood Later, when the acute phase of hyperemia and mucosal edema is replaced by cicatricial contraction, physical signs of low sigmoid obstruction are present

The terminal ileum is frequently in the low pelvis, and in the area of active irradiation Therefore, the symptoms of complete or incomplete low small intestinal obstruction often appear earlier than obstruction of the low sigmoid

It seems important to advance the thought that a patient who has received irradiation to the pelvic region and later complains of abdominal pain, change in bowel habit, nausea and vomiting, does not necessarily have a recurrence or extension of the original disease There may be a stenosing and partially obstructing lesion, the late-result of irradiation This may be corrected by the proper surgery, with the outlook much more favorable

Some obstructive lesions of the sigmoid regress, and the normal lumen is restored This follows, at times, as the result of a proximal defunctionalizing colostomy If the obstruction regresses, it can be due only to a lessening of the infection and the disappearance of the edema, which is caused by the constant trauma of the bowel content Scar tissue could not be expected to regress

The following five case histories are presented and the surgical treatment described

CASE REPORTS

Case 1 —Mrs H, age 63, was admitted to the hospital 3-8-'35 Chief complaint was postmenopausal bleeding Tissue section of the diagnostic curettage specimen proved the lesion to be adenocarcinoma of the corpus uteri Intra-uterine irradiation for a total of 3,000 mg h was given Thirty-five days after the completion of the irradiation, an abdominal total hysterectomy was performed At this time, an area of 6 cm of the sigmoid, found in intimate contact with the posterior wall of the uterus, was thickened and edematous Appendices epiploicae in this area were firmly attached to the serosa of the

* Irradiation under the direction of John F Hynes, M D, Director of Carpenter Memorial Clinic, the Memorial Hospital, Wilmington, Delaware.

sigmoid The patient complained within two weeks after irradiation of rectal pain, and tenesmus, with the passage of mucus and blood These symptoms improved, but never entirely disappeared She was readmitted to the hospital 12-27-'39 This was four and one-half years after irradiation The clinical picture was that of large-intestinal obstruction The abdomen was markedly distended and asymmetric Persistent vomiting of duodenal and high jejunal fluids At operation, under spinal anesthesia, the large intestine was found to be dilated and distended to the area in the low sigmoid described above, found at the time of operation A distinct mass was palpable A cecostomy was established Cecostomy was closed 1-5-'40 She recovered, and later developed a rectovaginal fistula This patient, now age 74, is living and well The fistula has closed There is no evidence of the primary disease

Case 2—Mrs T, age 35, was treated for a pathologically-proven carcinoma of the cervix She received 2,700 r through four fields—two anterior and two posterior The areas were alternated, giving 300 r a day to two fields External irradiation was begun 4-28-'41 On 5-12-'41, she complained of abdominal pain and diarrhea, and was readmitted 6-7-'41 On 6-30-'41, she received 3,000 mg h to the cervix On 8-15-'41 which was three and one-half months after treatment, she was readmitted and had an abdominal exploration At this time, she had paroxysmal, cramp-like abdominal pain with visible peristalsis

Operation—8-17-'41 The terminal ileum, from a point 6 cm proximal to the cecum was found to be fixed to the right lateral pelvic wall It formed a hard, and indurated fixed mass There was a 6-cm area of complete necrotic ileum through which some leakage had occurred The ileum, for 30 cm proximal to this area, had edematous and thickened walls A resection of 30 cm of the terminal ileum was undertaken, with an end-to-side ileocecostomy A Witzel enterostomy 30 cm proximal to the anastomotic site was established The wound sloughed, and there was no attempt at healing in the zone of irradiation The patient died 11-1-'41 This was two and one-half months after operation Death was due to hemorrhage from the deep epigastric artery

Case 3—Mrs O'B, age 30, had an abdominal exploration in Pennsylvania previous to her admission to this hospital Exploration, only, was made at that time There was a large agglutinated mass which filled the entire pelvis Numerous areas in the great omentum, which were secondary implants from a primary papillary carcinoma of the ovary The peritoneal cavity contained 2,000 cc of free fluid, which was aspirated Abdominal paracentesis was done, in this same hospital, on four successive occasions An average of 1,500 cc of fluid was removed each time

This patient was then admitted to the Memorial Hospital, for radiation therapy External irradiation was completed 5-16-'35 There was a definite reduction in the abdominal mass The ascites had not recurred She had gained eight pounds A second cycle to the right pelvis, of 1,200 r was administered through an anterolateral and posterior pelvic field Due to reduction in the size of the abdominal mass, increased mobility, and the absence of recurrent ascites, exploration was decided upon On 5-27-'36, an abdominal total hysterectomy was performed There was a large cystic mass between the leaves of the left broad ligament and also in the prevesical space The pathologic diagnosis was papillary cyst adenocarcinoma of the ovary, with metastases On 6-16-'39 a firm mass was palpable in the rectovaginal septum Celiotomy was done, under direct vision Radon seeds were implanted.

The patient was readmitted to the hospital 7-12-'41 She complained of abdominal fullness, recurring cramp-like pains, nausea, and vomiting The picture was one of low, small intestinal obstruction On operation, 7-16-'41, the following findings were noted

There was complete obstruction at the ileocecal junction The terminal ileum was firmly agglutinated to the posterior parietal peritoneum and to the right lateral bladder wall The fixation and angulation produced the obstruction The diameter of the

IRRADIATION INJURY TO INTESTINE



FIG 1—(A) Case 4 Barium enema, 11-23-40, showing an obstructive narrowing in the low sigmoid six months after beginning of therapy
(B) Case 4 Further progress in the constricted area ten days later (12-3-40)
(C) Case 4 Barium enema six weeks after closure of colostomy (9-3-'41)
(D) Case 4 Post evacuation enema (9-3-'41)

terminal ileum was four times that of normal. The walls were thickened and edematous. These changes were seen for many feet proximal to the area of obstruction. The small intestine contained, on decompression, 2,000 cc of fluid. A lateral ileocolostomy was established after decompression. The ileum, 30 cm proximal to the point of obstruction, was anastomosed to the transverse colon. The patient was discharged 8-3-'41, and died 8-6-'44 of a further extension of the original disease, six years and three months after the original irradiation.

Case 4—Mrs S, age 37, was admitted to the hospital 5-20-'40. The following treatment for carcinoma of the cervix was given: Deep therapy through four fields, two anterior, and two posterior, 3,000 r to each field. Radium 4,500 mg h to cervix 5-22-'40. On 5-28-'40, 750 mg h and a like amount 5-20-'40.

She was readmitted 11-19-'40. For four weeks she had complained of cramp-like abdominal pain and a mucus diarrhea, with blood at times. There was a palpable mass in the L L A Q, medial to the inguinal ligament. A barium enema showed a persistent filling defect in the pelvic sigmoid. The lumen was greatly diminished.

Her complaints persisted under bed rest, a low residue diet and warm colonic irrigations.

Abdominal exploration on 12-4-'40. This was eight months after the completion of irradiation. There was a sharply defined area of the sigmoid, 12 cm proximal to the rectosigmoid junction. This area was 8 cm in length, the sigmoid wall at this point was thickened and edematous. No lumen could be demonstrated. The walls of the sigmoid, for 12 cm proximal to the sharply defined area, were slightly thickened and edematous. This was due to the distal obstruction. A temporary colostomy was established 20 cm above the constricted area. She was discharged 1-5-'41. The abdominal cramp-like pain and diarrhea had entirely disappeared. She had gained weight.

She was readmitted 3-4-'41. A barium enema showed almost complete restoration of the lumen. The colostomy was closed. A barium enema one month later showed but a slight narrowing of the lumen. There were no abdominal complaints. She was examined 6-12-'46, there was no evidence of any recurrence of disease.

Case 5—Mrs H, age 47, was admitted to the hospital, 9-1-'44, and treated for carcinoma of the cervix. She received 4,500 mg h to the cervix. She was readmitted, 9-15-'44, complaining of lower abdominal pain, with diarrhea. A tender mass was palpable in the left vaginal fornix. The impression was that of an acute exacerbation of a chronic salpingitis due to irradiation. She improved under treatment, and was discharged 9-21-'44. She was readmitted 3-20-'45. The complaints at this time were: Cramp-like lower abdominal pain, frequent liquid stools, with blood and mucus. Weight loss of 13 pounds in three weeks, and occasional vomiting. There was moderate fullness in both lower abdominal quadrants.

A barium enema, 4-4-'45, showed an obstructive area slightly proximal to the rectosigmoid junction. The diameter of the bowel at the point of maximum constriction was less than 1 cm. The obstructed area was constant and would not dilate under hydrostatic pressure.

Operation—4-16-'45. The sigmoid, left colon and a portion of the transverse colon showed the effects of distal obstruction. The colon was dilated, with edematous walls. The lumen contained many hard balls of fecal matter. About 2 cm proximal to the rectosigmoid junction there was a hard, firm mass in the sigmoid. It was 12 cm in longitudinal extent. The liver, uterus and adnexae were normal. A temporary, diverting right transverse colostomy was established.

Despite daily colonic irrigations from above-down, and from below-up, it was impossible to clear the colon. The patient complained of severe, recurrent, cramp-like pain in both lower abdominal quadrants. Frequent narcotics were required.

A second operation, a left inguinal colostomy, was performed on 5-18-'45. Through

IRRADIATION INJURY TO INTESTINE

a lower left rectus incision, it was possible to have the low sigmoidal lesion under direct vision. It began at the rectosigmoid junction. The walls were edematous, thickened and rubber like. This area extended upward for 4 cm. At this point there was a



FIG 2—(A) Case 5 Barium enema seven months after radiation (4-4-'45)
(B) Case 5 Barium enema (7-10-'45)
(C) Case 5 Three months later. There is still no change (11-12-'45)

hard, firm mass extending proximally for a distance of 8 cm. The mass was not intraluminal, but consisted of inflammatory thickening in the bowel wall and the mesentery. From the most proximal point of the mass, the epiploic appendices were thickened and

red for a distance of 30 cm. The sigmoidal mass was firmly agglutinated to the posterior parietal peritoneum in the right iliac fossa. The posterior surface of the right broad ligament was agglutinated to it, as were the numerous coils of small intestine by a cartilaginous-like induration. There was no evidence of lymphatic extension of the original pathology (Squamous cell carcinoma of the cervix).

With frequent injections of mineral oil and irrigations from the right transverse colostomy to the left inguinal colostomy, this portion was finally cleared of hard, firm lumps, consisting of dehydrated barium and fecal matter.

Barium enema ten months after radiation, and three months after a temporary diverting transverse colostomy, and two months after the left inguinal colostomy, showed no change in the filling defect.

A barium enema, 7-10-'45, shows a persistence of the filling defect in the sigmoid.

This case shows no change eight months after having put the area at rest. Resection should be done. It has been deferred because of a respiratory infection. The plan contemplated is to resect the lesion, and, at that time, close the left inguinal colostomy. Later at another stage, to close the transverse colostomy.

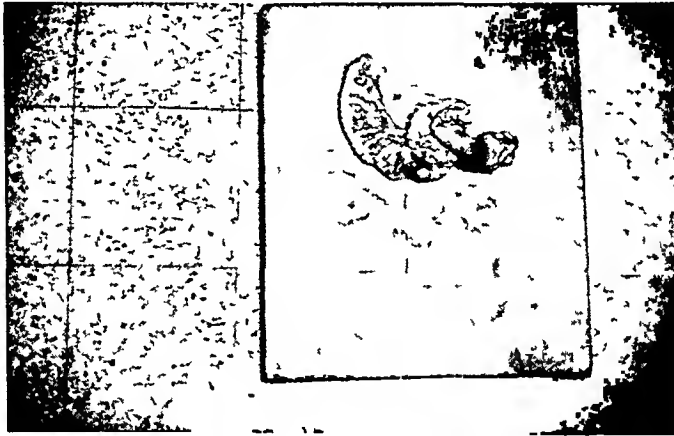


FIG 3—Kodachrome of the gangrenous resected ileum (30 cm)

Case 5 illustrates the inadvisability of forcing barium through an almost completely obstructing lesion, any considerable distance beyond the constricted area. In our experience, with both carcinomatous and irradiation-obstructing lesions of this degree, preliminary proximal diverting colostomy is indicated.

CONCLUSIONS

It is important to be aware of the fact that complaints of recurring, severe cramp-like pain occurring a few months or several years later, in patients having previously had irradiation therapy for cervix and corpus uteri carcinoma, may be due to the late-effects of irradiation. These may produce incomplete or complete obstruction due to vascular change and fibrosis following edema.

Abdominal exploration after appropriate study and observation is indi-

cated One must not assume that the picture is necessarily one of extension of the primary pathology

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THE ANATOMY OF THE PERI-ESOPHAGEAL VAGI

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THE REVIVAL OF CLINICAL INTEREST in vagotomy as a surgical procedure for peptic ulcer stimulated this investigation of the anatomy of the esophageal vagi. Examination of the standard text books of anatomy provided insufficient anatomic description of surgical value. However, McCrea,¹ Hovelacque,² and Mitchell³ have published excellent descriptions of the infra-aortic portion of the vagi and the innervation of the gastro-esophageal junction. Their studies showed that the right and left vagi and the esophageal plexus formed an extremely complex and varied arrangement of nerve structures.

Methods and Material—A total of 32 gross dissections on cadavers were carried out after the lungs and heart were removed, and the diaphragm sectioned through the esophageal hiatus. The esophagus and its associated vagal nerve structures were carefully examined. No attempt was made to define the very fine nerve filaments entering the musculature of the esophagus nor the sympathetic fibers emanating from the sympathetic trunk, the splanchnics or the peri-aortic plexus. The dissection was started at the point of reformation of the right and left trunks from the pulmonary plexus just below the bifurcation of the trachea, and continued down through the diaphragmatic hiatus. The formation of the complex anterior and posterior gastric plexus, and the branches to the coeliac plexus, were not examined. Diagrammatic drawings were made of each dissection, the sketches, pictured in Figures 2, 3, 4 and 5 were not drawn in proportion in any way but were intended to enable surgeons to visualize as a whole the complex arrangements of the peri-esophageal plexus in its variations from one individual to another.

Findings—As can be seen from examining the diagrams, the specimens all varied in the number of fibers forming the infra-aortic right and left vagal trunks, in the arrangement of the peri-esophageal plexus, in the way the anterior and posterior vagal trunks were formed and in the number of separate fibers that passed through the esophageal hiatus. In general, close examination revealed a basic conformity to four well-defined types (Fig. 1), those in which the right and left vagi communicated through anterior fibers (11 cases), those in which no communicating fibers could be found (1 case), those in which communicating fibers were all posterior (6 cases), and the last group in which communicating fibers were present both anteriorly and posteriorly (14 cases).

The right and left vagi after reforming from the pulmonary plexus, emerged along the lateral borders of the esophagus as a varying number of

separate fibers, usually one to four (Table I). These fibers remained lateral to the esophagus for a distance of one to two inches, often communicating or merging with each other. They then followed the course of the esophagus as it inclined to the left and became closely adherent to its musculature, arbor-

TABLE I
NUMBER OF SEPARATE FIBERS PRESENT IN VAGAL TRUNKS
EMERGING FROM THE PULMONARY PLEXUS

	Number of Fibers			
	1	2	3	4
Right vagus	12	10	7	3
Left vagus	9	12	11	0

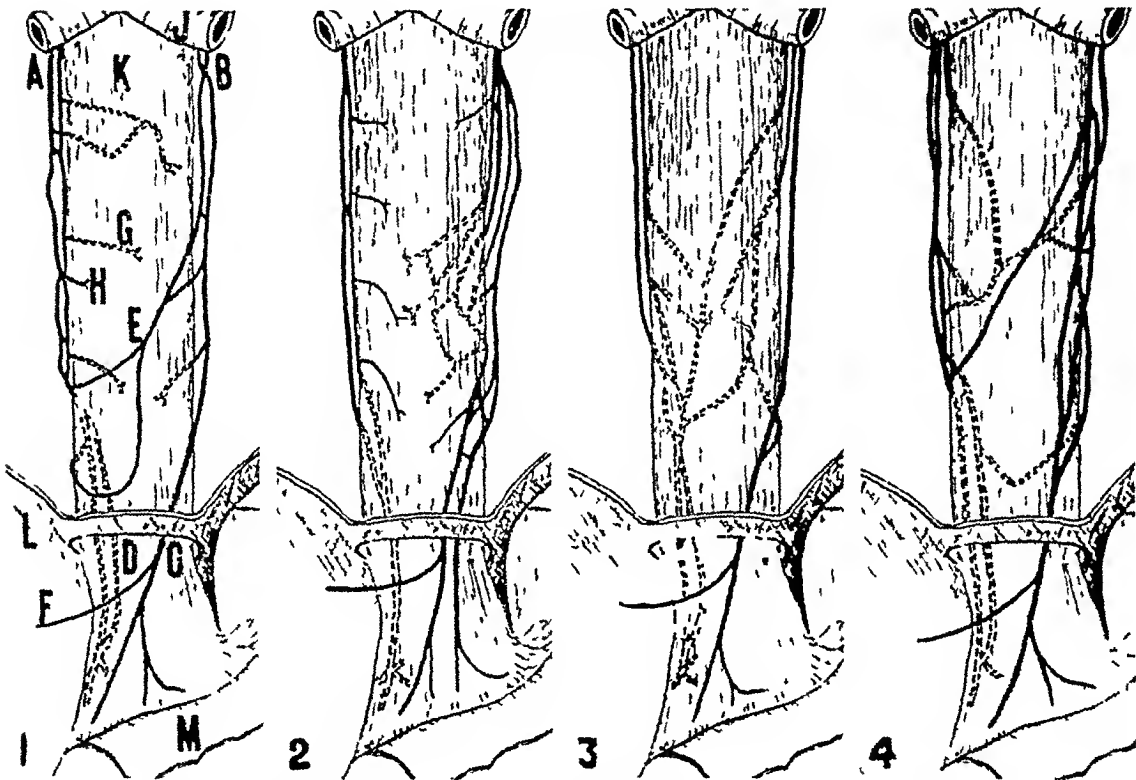


FIG 1—The diagrams illustrate four different types of anastomosis between the right and left vagal trunks in the formation of the peri-esophageal vagal plexus (1) Anterior communicating branches only, (2) no communicating branches, (3) posterior communicating branches only, and (4) anterior and posterior communicating branches (A) right vagal fibers, (B) left vagal fibers, (C) anterior vagal trunk, (D) posterior vagal trunk (2 fibers in this case), (E) anterior communicating vagal fibers, (F) Hepatic fiber, (G) posterior short esophageal fiber, (H) anterior esophageal fiber, (I) trachea, (K) esophagus, (L) portion of diaphragm showing diaphragmatic hiatus, and (M) stomach with peritoneum stripped off to expose gastro-esophageal junction. The vagal branches lying anterior to the esophagus are shown as solid line, the fibers lying posteriorly as double dotted lines. The right and left vagal trunks are shown pulled away from the lateral walls of the esophagus, to simplify the illustrations.

izing and sending out communicating fibers to each other as described above. At about the level of the distal third of the esophagus the anterior and posterior vagal trunks usually became well-defined, as a rule, the posterior as a continuation of the main fibers of the right vagus and the anterior as a continuation of the left vagal fibers. The right and left vagal trunks usually

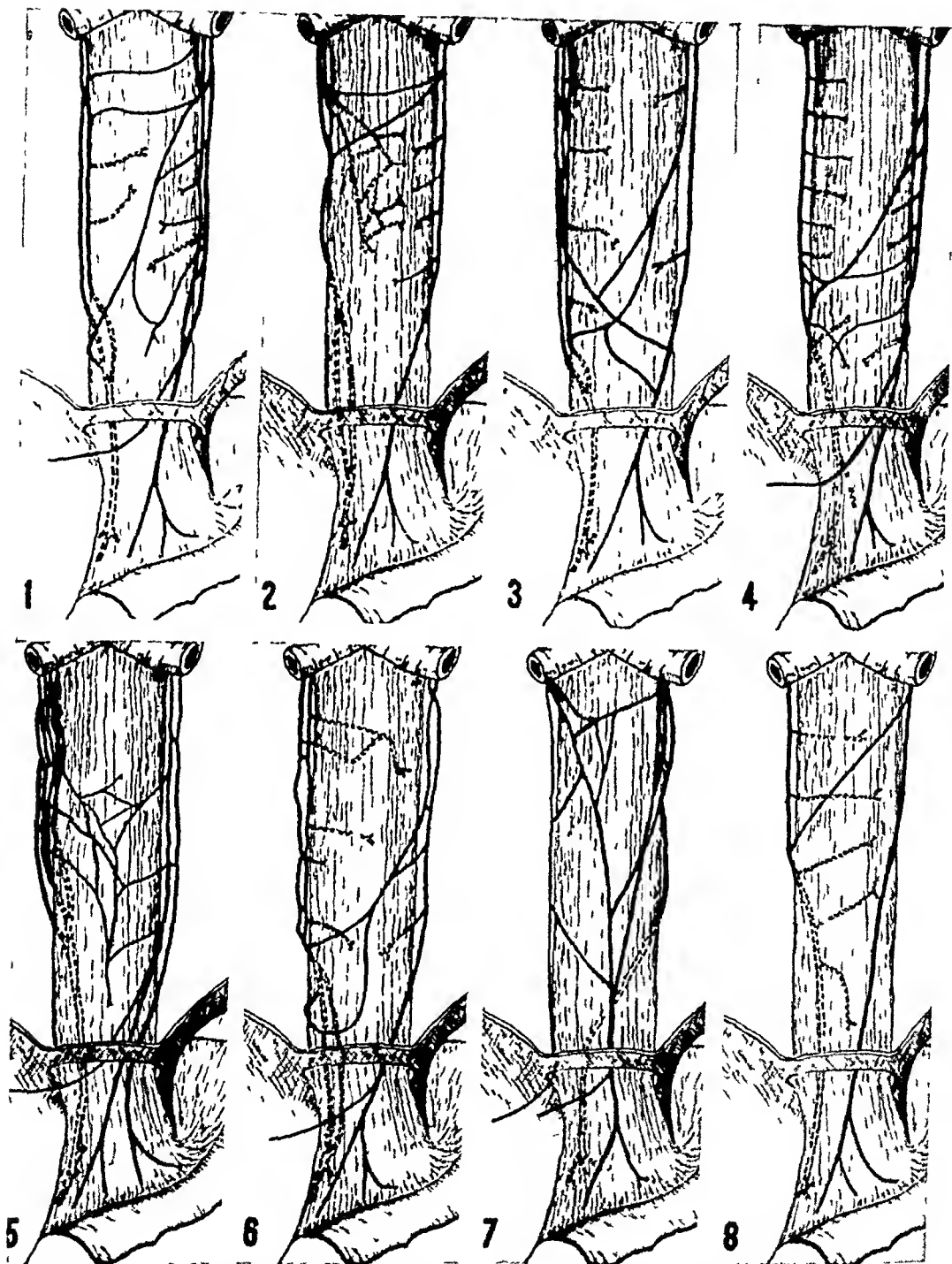


FIG 2—Diagrams illustrating the variation in the origin of the infra-aortic vagi, the mode of formation of the peri-esophageal plexus, and of the anterior and posterior vagal trunks, and their passage through the esophageal hiatus. In these eight specimens only anterior communicating branches were found.

ANATOMY OF PERI-ESOPHAGEAL VAGI

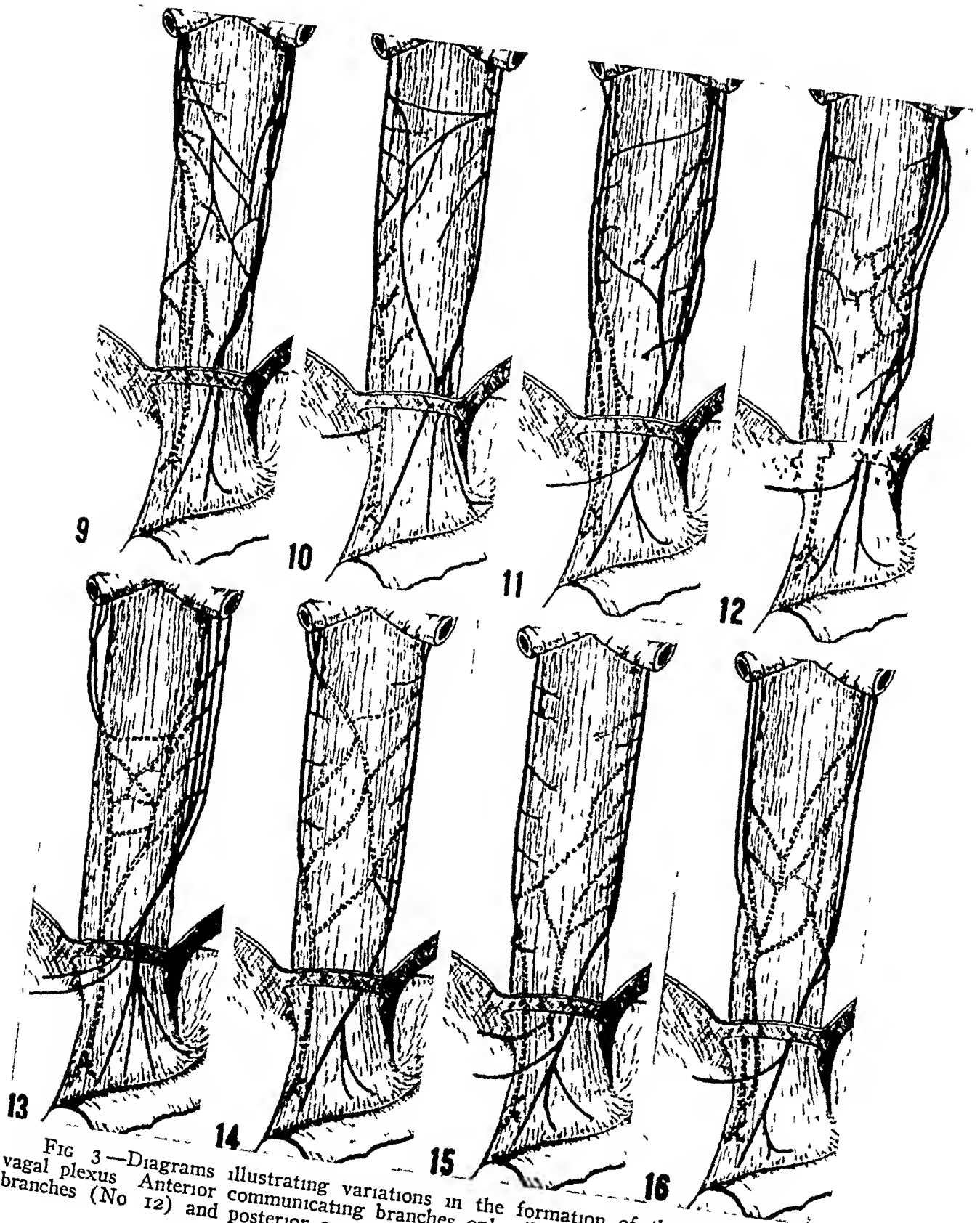


FIG 3—Diagrams illustrating variations in the formation of the peri-esophageal vagal plexus. Anterior communicating branches only (Nos 9-11), no communicating branches (No 12) and posterior communicating branches (Nos 13-16)

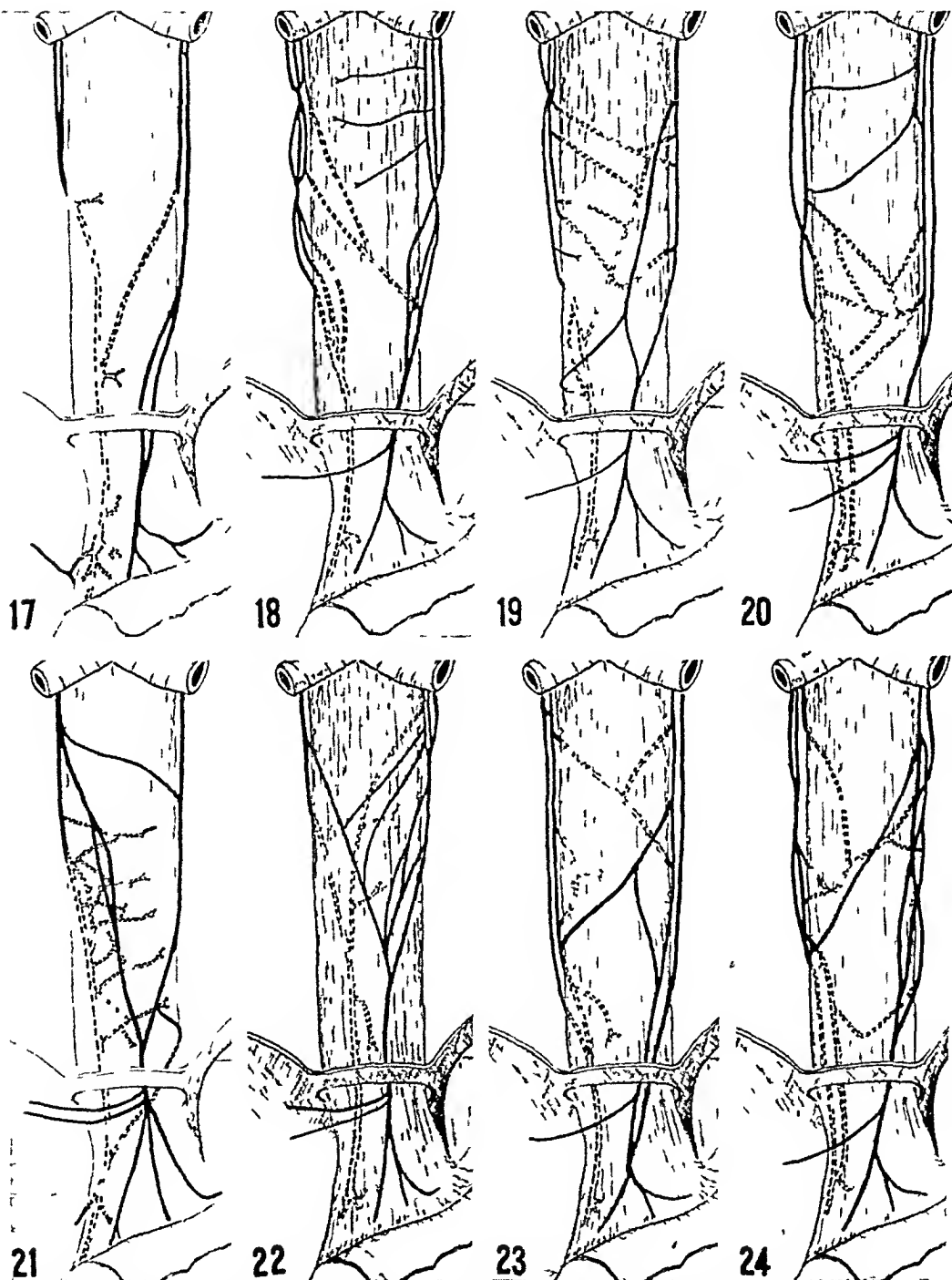


FIG 4—Diagrams illustrating variations in the formation of the peri-esophageal vagal plexus. Posterior communicating branches (Nos 17 and 18), anterior and posterior communicating branches (Nos 19-24)

ANATOMY OF PERI-ESOPHAGEAL VAGI

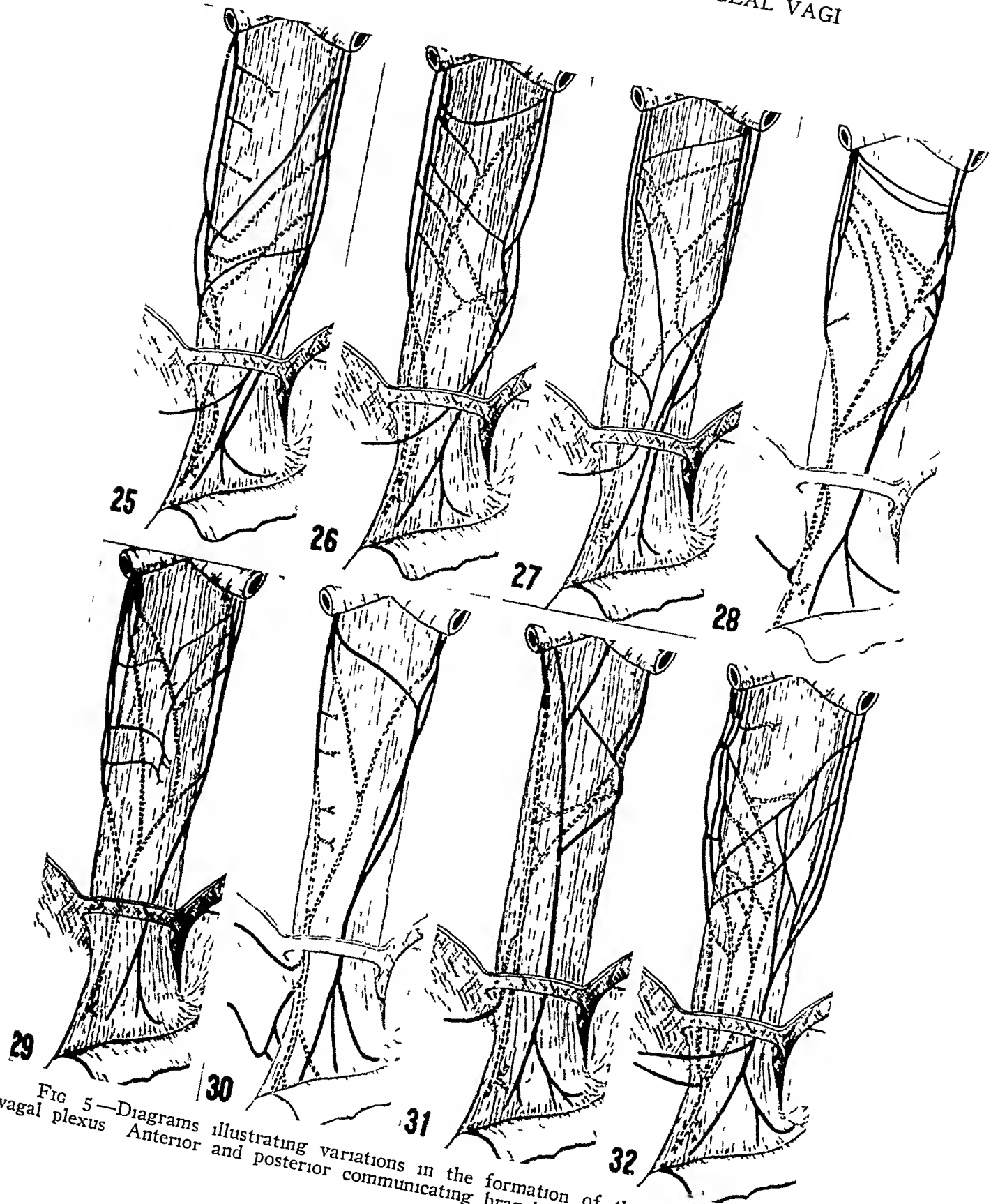


FIG 5—Diagrams illustrating variations in the formation of the peri-esophageal vagal plexus Anterior and posterior communicating branches (Nos 25-32)

were connected with each other by communicating branches, either anterior (No 1-11) or posterior (No 13-18) communicators, or both (No 19-32). Frequently the anterior communicating branch arose from the right trunk while the posterior communicator arose from the left trunk. The communicating branches not only served to connect the two vagal trunks but also contributed to the formation of an anterior or posterior esophageal plexus or plexus gulae. Both the right and left vagal trunks supplied short esophageal branches which ran transversely and entered the substance of esophagus. The right and left vagal trunks formed and reformed in their course alongside the esophagus, but tended to maintain the approximate number of branches they contained after their origin from the pulmonary plexus. Within two inches of the esophageal hiatus, the vagi lay both anterior and

TABLE II
NUMBER OF SEPARATE VAGAL FIBERS PASSING THROUGH
THE ESOPHAGEAL HIATUS

	Number of Fibers			
	1	2	3	4
Total		9	17	6
Posterior	20	11	1	0
Anterior	20	10	2	0

TABLE III
ORIGIN OF HEPATIC FIBERS

Arising from anterior vagal trunk	19
Arising from posterior vagal trunk	3
Arising from both vagal trunks	3
Not found	7

posterior to the esophagus. However, in a few instances, the vagal trunks pursued a course parallel to the esophagus without assuming the anterior or posterior position until just inside the hiatus.

The total number of vagal fibers passing through the esophageal hiatus were not limited, as commonly conceived, to an anterior and posterior branch, but frequently came through as three or four branches (Table II). The posterior vagal trunk passed through the hiatus as a single fiber in 20 specimens, as 2 fibers in 11 specimens, and as 3 fibers in one specimen. The anterior vagal trunk came through as one fiber in 20 specimens, as 2 fibers in 10 specimens, and as 3 fibers in 2 specimens.

The hepatic nerve or nerves were traced through the layers of the lesser omentum to the liver. In 19 dissections, the hepatic nerve or nerves arose from the anterior vagal trunk, in three cases from the posterior trunk, and in three cases from both the anterior and posterior vagal trunks. In seven cases, the hepatic nerves were not defined (Table III). In six specimens the hepatic nerve (Nos 1, 4, 5, 13, 26 and 27) arose from the anterior vagal trunk above the esophageal hiatus and passed through the foramen as

a separate fiber. Similarly, in two cases (Nos 7 and 31) the hepatic nerve arose from the posterior vagal trunk above the hiatus. In one case, (No 7) the hepatic nerve was traced as a direct branch of the right vagal trunk. In this case the posterior vagal trunk appeared to be derived directly from the left vagus. In another dissection (No 27) the hepatic nerve was a direct continuation of the communicator nerve. In a number of cases (Nos 5, 8, 9, 22 and 23) the interesting observation was made of esophageal branches which were traceable intrinsically through the esophageal muscle fibers for considerable distance down towards the esophageal hiatus. None of these could be followed definitely through the hiatus.

From the above description of the peri-esophageal vagi it is apparent that vagotomy can be accomplished by an approach through the left chest exposing the infra-aortic esophagus⁴. Thorough vagal section can be obtained either by careful search, not only for the vagal trunks, but also for the main connector branches. By means of peri-esophageal stripping, surgical denervation can thus be accomplished. Similarly, if an approach through the upper abdomen is considered necessary, vagotomy can be also effected by mobilizing the lower part of the esophagus and clearly exposing the boundaries of the hiatus to reveal all the vagal branches passing through it.

SUMMARY

The mode of origin, peri-esophageal ramifications, and course through the esophageal hiatus of the infra-aortic vagi in 32 cadaver specimens, are described and illustrated by separate diagrams.

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PROLONGED INTERCOSTAL NERVE BLOCK IN UPPER ABDOMINAL OPERATIONS

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IN A PREVIOUS REPORT¹ the use of intercostal nerve block with a long-acting anesthetic agent in connection with upper abdominal operations was described. The results obtained in this small series of 20 cases were favorable, and it was decided to continue its use to secure further information and make a better evaluation of its usefulness and possible rôle in postoperative care.

The original thought was that two possible advantages might be obtained, the elimination or reduction of postoperative pain and discomfort and a lower incidence of postoperative pulmonary complications. These are interrelated. The pulmonary complications usually start with an area of atelectasis at which a pneumonic process later supersedes. This primary atelectasis is due to greatly reduced respiratory excursions produced by a combination of factors all dependent upon pain from the abdominal incision and attempts by the patient and doctor to alleviate them. These factors are splinting of the diaphragm, tight abdominal dressings and binders, reluctance to take deep breaths, and to cough up gathering mucous plugs, to morphine and other analgesics, and the tendency of the patient to remain in one position.

The problem is not a new one, and several efforts in the past to find the proper solution made progress in the right direction. Gius² found that in two cases which developed postoperative atelectasis, paravertebral block with procaine of the nerves supplying the operative area (in these instances lower thoracic and upper lumbar following appendicectomy) eliminated the pain from the wound, allowing deep breathing, easy coughing, and freedom of movement. The offending plugs of mucus and bronchial secretions were dislodged and expectorated with rapid reexpansion of the involved lung areas.

An attempt was made by Crile³ to produce a local anesthesia of the wound by injecting one-sixth to one-half per cent solution of quinine and urea hydrochloride. The anesthesia obtained was satisfactory, lasting for several days, but the method was discarded because it produced a fibrinous exudate with occasional suppuration at the sites of injection.

Another effort along this same principle was made by Capelle,⁴ who tried the continuous administration of a procaine solution into the wound area. He used several large, thin, curved, hollow needles which were placed like retention sutures and served as outlets to irrigate the wound with the anesthetic solution when required. This method has been discarded for technical reasons.

A few years ago Bartlett⁵ wrote the classical description of the blocking of the lower intercostal nerves to produce upper abdominal anesthesia. He

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INTERCOSTAL NERVE BLOCK

pointed out that in the midaxillary line they were easily accessible and could be reached with great accuracy. Bartlett described the use of the block of the 6th to the 11th intercostal nerves as producing anesthesia of the upper abdominal wall with relaxation of the musculature, and showed how it could be used to advantage, when combined with light general anesthesia in operations upon the upper abdomen.

Using this technic, and adapting it to this particular problem of postoperative atelectasis, Starr and Gilman,⁶ in a series of cases, performed intercostal blocks about 24 hours postoperatively, and showed that there was a marked increase in pulmonary ventilation. The relief of pain allowed the patients to move about more readily, coughing was much easier with ability to raise sputum enhanced, and there was an increase in vital capacity.

The next step was reported by Zollinger⁷ who, in a series of 15 cases, performed intercostal blocks with a solution of eucupin in oil to obtain anesthesia of several days' duration. From 15 to 5 cc were injected in each space. Measurements of vital capacity showed an increase over the readings obtained in a control group who did not have the block. The resulting anesthesia using both unilateral and bilateral blocks was not uniformly good, but he stated the method warranted further trial.

METHOD

The technic used for performing the intercostal block was that described by Bartlett and adapted for use in this respect as already reported. Briefly, it is as follows. After the anesthesia for the operation had been started, the arm was raised above the head, thus, exposing the midaxillary line for injection. The area was sterilized and sterile technic was used throughout the procedure. One and one-half to two cubic centimeters of solution were deposited just under the inside and lower border of ribs 6 through 11. In the first few cases the injections were made before the anesthetic for the operation was started. This proved unsatisfactory since the pain incidental to the procedure was distressing to the patient. In all successive cases the block was done after the induction of anesthesia. When spinal anesthesia was being used, the intercostal block was done after the level of anesthesia had risen to the fourth or fifth thoracic segment. With a general anesthetic, it was done after induction while an assistant maintained the anesthesia. In this way the patient was spared the ordeal of multiple injections.

At first all cases received a bilateral block, but it was soon realized that if the incision were placed one inch or more from the midline a unilateral block would be sufficient.

TABLE I

Bilateral	42
Right	39
Left	19

The number of each done is shown in Table I. The tendency was to do only the right side for operations on the biliary system, and the left for gastric

surgery Ventral and epigastric herniae received bilateral blocks as did those cases with midline or transverse incisions

There was no attempt at selection of cases Every upper abdominal operation, in which the anesthetic was administered personally, also received an intercostal block There was no effort to choose those cases which might appear more favorable The reverse might be more likely, since it was the poorer risks which received personal attention, a staff of nurse anesthetists being available for the uncomplicated cases It was thought best to take every case that came along in an endeavor to obtain a true picture of the efficacy of the procedure

A variety of anesthetic agents was used in these cases, as is illustrated in Table II

TABLE II

Spinal	24
Continuous spinal	17
Local	1
Sodium pentothal	3
Spinal and cyclopropane	1
Nitrous oxide-oxygen-ether	3
Cyclopropane oxygen	7
Cyclopropane oxygen ether	44

As a rule the gastric resections were done under continuous spinal anesthesia, the others being fairly evenly distributed If no special indication or contraindication existed to influence the choice of anesthetic, the selection was left to the surgeon or patient, depending upon who had a marked preference for any method

The operative procedures performed are listed in Table III Practically every upper abdominal procedure is included in this group of cases

TABLE III

Cholecystectomy	37
Cholecystectomy and appendectomy	14
Common duct exploration	4
Cholecystostomy	2
Cholecystectomy and hepatoduodenostomy	1
Gastric resection	9
Gastro enterostomy	17
Gastrostomy	5
Gastrostomy	3
Closure of gastric fistula	1
Exploratory for inoperable carcinoma	4
Epigastric hernia	3

The time of operation varied, some of the procedures taking less than one hour, others up to four hours Most of the cases took between 15 and 2 hours The sex distribution was fairly even—54 males and 46 females

Most of the patients fell into the older age-group, as seen in Table IV This was to be expected since these lesions most commonly occur in such age-groups Eighty per cent of the patients were over 40 years of age, and 50 per cent were over 50 years of age

INTERCOSTAL NERVE BLOCK

TABLE IV

20-29	5
30-39	15
40-49	30
50-59	29
60-69	14
70 and over	7

The agent used in this series of cases was Novest-Oil, which is a solution of monacaine base in oil of sweet almonds with the following formula

Monacaine base	0.02 Gm
Benzyl alcohol	0.05 Gm
Benzocaine	0.03 Gm
Oil of sweet almond	to 1.0 cc

This anesthetic in oil is one of those commonly used for the relief of pain following rectal operations, and since it appeared to have no deleterious effects when injected around the rectum it was selected for use in this procedure

The patients in this group were not informed of the reason for the intercostal block and many of them did not even know that it had been done. No mention was made of the fact that they might expect relief from or abatement of their postoperative pain. The usual orders for postoperative sedation with an opiate, either morphine sulphate or pantopon were left, to be given if the patient complained of pain. No attempt was made to withhold needed sedation from the patient.

RESULTS

It was decided to judge the efficacy of the block by the amount of sedation required to eliminate any pain the patient might have during the postoperative period. Table V shows the tabulation of the number of doses of opiate required by the patients.

TABLE V

None	42
1	26
2	11
3	5
4 or more	16

The block was considered successful if three or less injections were administered during the postoperative period, and unsuccessful if four or more were administered. This has been an arbitrary division but is based on clinical observation. Often one dose was given while the patient was reacting from the general anesthetic to control his restlessness and excitement. In some instances opiates were given at bedtime for sleep, the nurses taking advantage of the fact that an order had been left to give the patient a good night's sleep.

Therefore, on the basis of these figures, the intercostal block produced the desired analgesia in 84 cases and failed in 16 cases. Some of these failures

might be due to psychic reasons, since patients who knew they were submitted to major surgery expected pain and called for sedation at the slightest discomfort. Most, however, were probably due to inaccuracy in the technic, the anesthetic solution not being deposited in close enough proximity to the nerve trunk. Technical difficulty was encountered in some patients of marked obesity where three-inch needles had to be used to reach the ribs. Some patients who became markedly distended required sedation for their distention rather than for pain at the operative site.

There were seven deaths in this series as follows

- (1) Acute left ventricular failure on the 3rd postoperative day
- (2) Peritonitis and uremia
- (3) Intestinal obstruction followed by atelectasis, pneumonia, evisceration, wound infection and pulmonary embolus
- (4) Coronary occlusion on the 15th day
- (5) Pulmonary embolus on the 15th day
- (6) Pulmonary embolus on the 10th day
- (7) Carcinomatosis

None of these can in any way be attributed to the intercostal block.

There were three cases of atelectasis in the 1st postoperative days, which cleared spontaneously when the patient was encouraged to cough and pounded on the back. Tracheal suction was attempted but the catheter rarely entered the trachea, the desired result being obtained when the patient coughed from stimulation of the pharynx by the catheter. In all these cases the block was successful when judged by the criterion of absence of postoperative pains, none of them requiring sedation. However, it was difficult to obtain the cooperation of these patients to cough, due perhaps to a combination of sluggish mentality and language difficulty. However, persistent personal attention on the part of the surgical house staff impressed them with the importance of coughing and expectorating plugs of mucus.

There was one case of bronchopneumonia in an extremely uncooperative patient who had no pain relief, requiring sedation every four hours for three days. In one patient who had a successful block but became severely distended a pneumonia developed on the 7th postoperative day.

There were four instances of right pleural effusion, all in cases which had successful results from the block. These absorbed spontaneously, although one required thoracentesis on two separate occasions.

DISCUSSION—Since the relief of postoperative pain is the desired result and the detrimental features of the postoperative course which are to be eliminated all stem from this, it was decided to accept pain relief as the criterion for a successful block. It was found that on this basis good results were achieved in 84 per cent of the cases. There are several reasons for the failure in 16 per cent. Although the block itself is easy to perform, there are six nerves to be injected, and failure to anesthetize any one of them renders the whole procedure worthless. Many of these patients, especially the gall-

bladder group, are inclined to obesity, making the block technically difficult. In several cases, needles used ordinarily for lumbar puncture were substituted here to reach the desired depth. Another technical factor was the small quantity of fluid deposited at each space. Never more than 2 cc was used in one place, since there is some danger of abscess formation from the pooling of an oily solution in one place in the tissues. Intercostal block when done with an aqueous solution as procaine for anesthesia rarely fails, for here 5 cc are used at each interspace. In a few of the cases the incision was probably made too near the midline and overlapping innervation from the other side negated the analgesia in unilateral blocks.

As is more or less inevitable following surgical procedures and anesthesia, some of these patients developed varying degrees of abdominal distention and required sedation for relief of the accompanying pain. Although in these instances the opiates were not given for pain arising from the incision and operative procedure, still it is counted as postoperative sedation in the final tabulation.

There are several interesting features about the three cases which developed postoperative atelectasis. They were all women who had had cholecystectomies performed under cyclopropane-oxygen-ether anesthesia, were all from the same ward, and were all operated upon within a space of three weeks by different surgeons. The anesthetic used and the fact that there were none under spinal anesthesia might lead one to conclude that inhalation anesthesia might be a predisposing factor. This has been shown to be not true in large series of controlled cases. More likely, is the fact that all these cases were from the same ward and in a short space of time and, hence, were due to a lack of attention from the nursing staff in regard to emphasizing to the patient the importance of coughing up gathering plugs of mucus. When there is a training school and a rapid turnover of student nurses on a floor a situation like this may occasionally develop, especially with a shortage of experienced personnel as occurred during the war years. This finding again lays stress upon the fact that attention to the frequent changing of position and encouragement to cough are essential to the prevention of postoperative pulmonary complications.

The four cases which developed pleural effusions deserve further consideration. All were females upon whom cholecystectomy had been performed, three under spinal and one under general anesthesia, by two different surgeons. In all instances there was only a unilateral intercostal block done on the right side which was successful for relief of postoperative pain, and in all instances the pleural effusion occurred on this same right side. In three of the patients the fluid was absorbed without any interference, but in the fourth, thoracentesis was done on two occasions to remove a total of 1,100 cc of fluid, which was clear and from which no organisms could be cultured.

The etiology of this sterile fluid seems to be some irritant stimulating the pleura. Probably when the block was being done some of the fluid was inadvertently injected into the pleural space with the resultant effusion. The proximity of the pleura to the intercostal nerve is thus stressed and great care

must be taken at each injection to make sure that all is deposited in the tissues and none in the pleural space. It had been hoped that the agent used would not stimulate the pleura or be an irritant, but apparently in some cases it did. Most likely it was the oily solvent that proved to be the irritating factor.

The incidence of postoperative pulmonary complications in the group of cases in which the block was successful in relieving pain was very low. The three cases of atelectasis responded nicely to conservative "stir-up" therapy, and the one case of pneumonia developed on the 7th postoperative day following a severe abdominal distention at a time when the block could no longer be of use. This is undoubtedly much better than would have been obtained in a similar group of patients and operative procedures had they not received the intercostal block.

The clinical picture presented by these people in their postoperative period was very gratifying. They were free from pain or suffered only slight discomfort in most instances. When requested, they were able to take deep breaths or cough without any pain. They moved about in bed freely and were comfortable. The difference from the average patient who has gone through a similar procedure was remarkable.

In several of the cases an opportunity presented to study the patient on two different occasions after the same type of upper abdominal procedure, once with the block and the other time without it. The patients were never told that anything special was being done to alleviate their postoperative pain.

W. H. had a gastric resection done under continuous spinal anesthesia for an ulcer. He had no pain in the postoperative period and required no sedation. The intercostal block had worked perfectly. On the 14th postoperative day he suddenly exhibited the typical picture of peritonitis and was explored. No pathology was found and he was closed and returned to the ward. No block was done on this second operation, and the patient required morphine at four-hour intervals for 48 hours. On the 10th day following his second operation, as he was about to get out of bed, he died suddenly. Postmortem examination showed a large pulmonary embolus as the cause of death. Sections of several of the intercostal nerves were removed and examined histologically at this time (24 days following injection) and no trace of the oily anesthetic agent was found, nor were there any signs of damage to the nerves or their fibers.

H. H. had a gastric resection performed for a penetrating duodenal ulcer under continuous spinal anesthesia. He required morphine every four hours for the first three postoperative days. About six weeks following this operation a celiotomy was performed for closure of a gastric fistula. This time intercostal block was done, and the patient required no sedation postoperatively.

These two cases illustrate the response of the same patient to successive operative procedures both with and without an intercostal block and demonstrate its efficacy for the relief of pain.

In a third patient, S. H., two operations were performed, repair of a ventral hernia and removal of a common duct stone, both under spinal anesthesia.

intercostal block being done in both instances and with good results. This illustrates the fact that the same nerves can be injected twice with good results both times.

In none of the cases was there found any residual signs from the intercostal block. There were no permanent effects upon the nerves and no paresthesias or hypesthesias.

CONCLUSIONS

The blocking of intercostal nerves 6 through 11 with an anesthetic in oil will, in the majority of instances, give relief of postoperative pain.

The usual postoperative pulmonary complications expected following these procedures have been greatly reduced in number.

There exists a danger of pleural effusion if the oil is inadvertently injected into the pleural space.

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A TECHNIC FOR BLOCKING THE CAROTID SINUS NERVES

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IN ESTABLISHING the clinical diagnosis of an hyperactive carotid sinus reflex, the syndrome must be reproduced by digital compression of the carotid sinus region. In order to ascertain that the hypersensitivity of the carotid sinus is really causing the condition, the compression maneuver should fail to bring on this reaction after blocking the carotid sinus nerves by an analgesic solution. An accurate technic of blocking the carotid sinus nerves, therefore, renders indispensable assistance in confirming the diagnosis as well as in casting the prognosis, particularly, when surgical intervention for relief is planned. In searching through the pertinent literature dealing with the therapy of the hyperactive carotid sinus reflex, several authors (Weiss,⁸ in 1936, and White and Smithwick,⁹ in 1941) recommend diagnostic block of the carotid sinus nerves. No specific description of the technical procedure has appeared previously, perhaps with exception of a brief account given by Rovenstine and Cullen⁵ (1939). The technic presented here is based upon anatomic and radiologic studies, as well as on the clinical application in approximately 50 patients.

THE CAROTID SINUS REFLEX

To maintain the normal level of the blood pressure, the vascular tree is endowed at various places with nerve endings responding to distention. When stimulated, particularly by increased blood pressure, a message is sent through afferent nerves to the vasomotor area in the brain which relays this stimulation to efferent cardiac decelerators as well as to vasodilators. This restores the normal level of the blood pressure. The *carotid sinus reflex* is one of the important blood pressure moderators. Its implication was fully appreciated by Hering³ (1927), and Heymans⁴ (1933). The *stretch* receptors are located in the adventitia of the carotid sinus, *i e*, a dilatation of the common carotid artery at its bifurcation. The majority of the receptors are located within the wall of the root of the internal carotid artery (De Castro,² 1928), although they may also extend to the common and external carotid arteries. The *afferent limb* of the reflex arc is in the main the carotid sinus nerve, a branch of the glossopharyngeal, and to a lesser extent the vagus. After leaving the petrosal and nodose ganglia the impulse enters the brain at the medulla, whereupon it is relayed to the vasomotor area. *Efferent vagal fibers* effect slowing of the *cardiac activity*. Peripheral vasodilatation is mediated through sympathetic pathways. Although the vasodilatory

BLOCKING CAROTID SINUS NERVES

mechanism has not been accurately analyzed, it is assumed that this phenomenon is induced by the inhibition of vasoconstrictors and the activation of vasodilator nerves (Heymans, Bouckaert and Regniers,⁴ 1933)

THE ANATOMY OF THE RECEPTOR NERVES

The interruption of the reflex arc is conveniently performed by blocking its *afferent limb*, *i e*, shortly after its departure from the carotid sinus. As shown recently by Sheehan, Mulholland and Shafiroff⁷ (1941), the origin of these nerves is not simple, for they are interlaced as to form an intricate network which has been designated as the carotid sinus nerve complex. The latter anastomoses in a variable fashion with the glossopharyngeal, vagus, sympathetic and occasionally the hypoglossal nerves. The complex is located between and somewhat behind the fork of the carotid bifurcation.

TOPOGRAPHY OF THE CAROTID BIFURCATION

Since this location represents an important deep landmark for blocking the carotid sinus nerve complex, a brief account of its relations and variations shall be given here. The carotid bifurcation, situated within the carotid fossa of the anterior triangle of the neck, is encased in the fascial sheath which encloses the common carotid artery, including its branches, the internal jugular vein and the vagus nerve. This sheath rests upon the prevertebral muscles which harbor in their fascia the cervical sympathetic trunk. The superior laryngeal nerve is often included in the block, because it travels in close proximity to the posterior aspect of the carotids on its way to larynx. The *carotid sinus nerves* course within the carotid sheath in front of the prevertebral muscles towards the gates of the basis of the skull. The relation of the carotid bifurcation to the skeleton is variable. In the upright anatomic posture it is located at the upper border of the thyroid cartilage. Because this relationship changes, particularly with the neck in extension, it is of but little use as a landmark in the blocking procedure. For practical purposes, more attention is paid to the relation of the carotid sinus to specific points of the spine. Commonly, the carotid bifurcation is placed in front of the anterior tubercle of the transverse process of the 4th cervical vertebra. According to Schwalbe⁶ (1878), and Binswanger¹ (1879), however, this position varies frequently. It may be found in front of the transverse process, anywhere from the 3rd down to the 5th cervical vertebra and, it is as a rule, somewhat lower on the left side. In individuals with a short neck the bifurcation is located at a higher level than in those with long necks.

TECHNIC OF NERVE BLOCK

Superficial and deep landmarks of the mandible and cervical vertebra are used as guides for directing the needle into the intercarotid space. The latter is located just above and behind the pulsating carotid sinus. The deposition of procaine solution into this area will block the carotid sinus nerve complex.

PREPARATION OF THE PATIENT

Prior to the actual insertion of the needle the following dictums should be observed (1) No preoperative medication should be given, for this will interfere with the test (2) In order to ascertain the existence of an irritable carotid sinus reflex, digital compression on the carotid bifurcation should precipitate a specific symptom-complex Positive reactions are noted by recording the changes of the blood pressure, quality and rate of the pulse of the radial artery, variations of the respiration and state of consciousness (3) The patient lies in the supine position on the examining table, with a soft

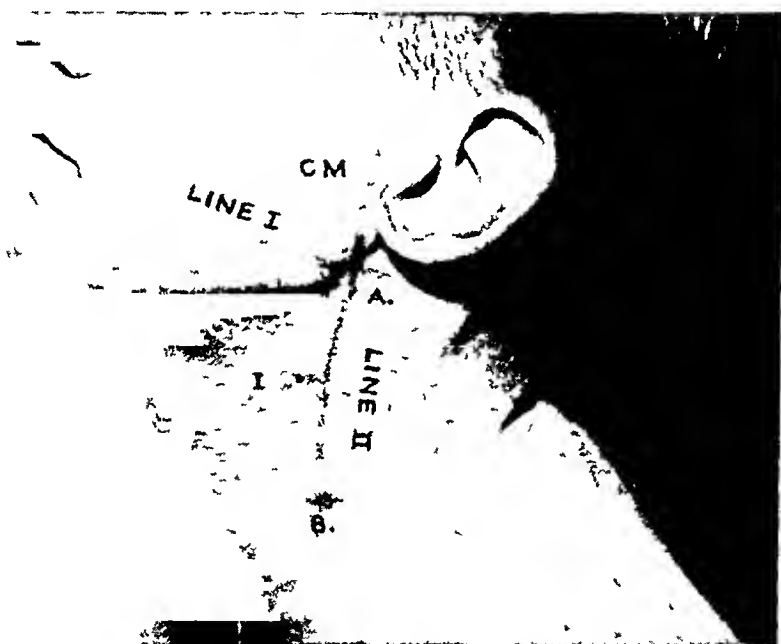


FIG 1—Skin markings to determine the site of introducing the needle Line I corresponding to the triturating line of the teeth Line II, perpendicular to Line I, runs through the projection of condyle of the mandible C M

- (A) is the point of crossing of Lines I and II
- (B) corresponds to the anterior tubercle of the 6th cervical vertebra
- (I) marks the site of introducing the needle 1 cm in front of the mid-point between A and B

pillow under the shoulders and a sandbag or aircushion under the external occipital protuberance These are arranged so that the head and neck are slightly extended in the midline position (4) *Plotting the site of injection* The point of introducing the needle is located on the lateral aspect of the neck at the height of the *anterior tubercle* of the 4th *cervical vertebra* This level is determined by drawing the following lines on the face and neck with a skin pencil (Fig 1) Line I extends posteriorly, from the angle of the mouth across the face on to the neck It corresponds to the triturating surfaces of the teeth (Fig 2A) Line II descends from the level of the posterior border of the mandibular condyle, forming a right angle with Line I at point A (Fig 1) Line II when properly placed, lies in the projection of

the posterior tubercles of the transverse processes of the 2nd, 3rd, 4th and 5th cervical vertebrae; because of the lordosis of the cervical spine Line II arrives at the anterior tubercle of the 6th cervical vertebra, *i.e.*, point B (Fig 2A) The posterior tubercle of the 4th cervical vertebra is located midway between points A and B Point A is the point of crossing of Line I and Line II, and B corresponds to the anterior tubercle of the 6th cervical vertebra (Fig 1) The skin projection of the anterior tubercle of the 4th cervical vertebra lies one centimeter anterior to the midpoint of A-B. This

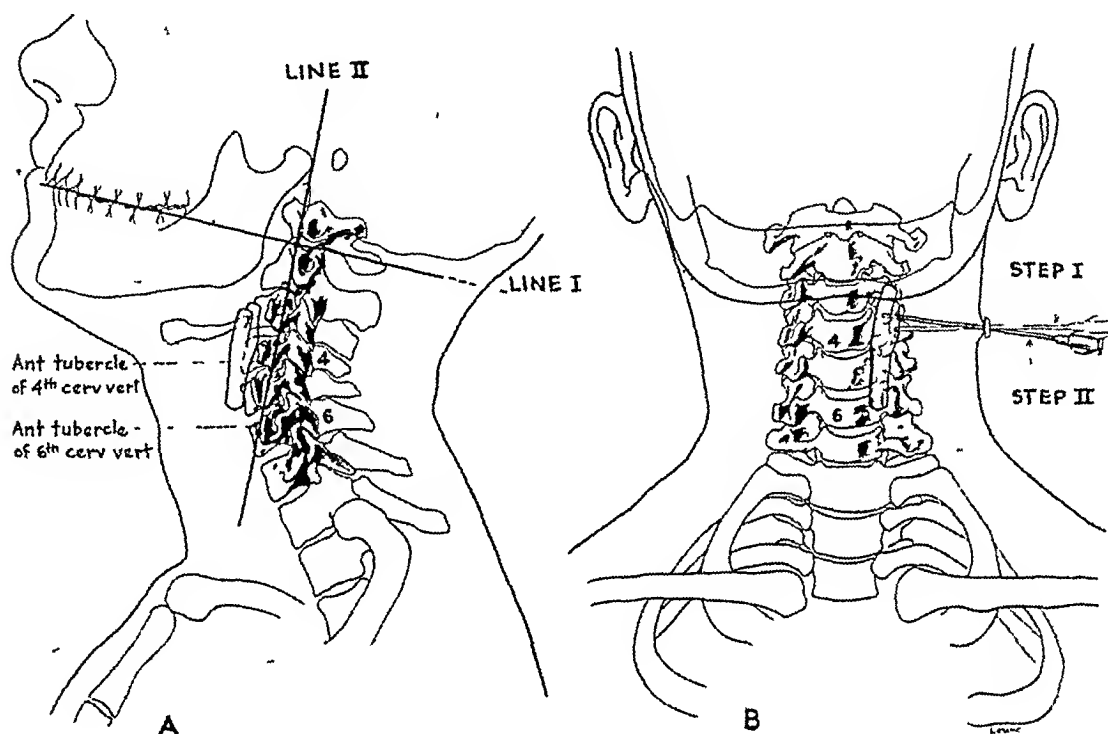


Fig 2—Tracings from radiographs of the bony landmarks of the neck

(A) shows Line I coursing along the trituration line of the teeth and the 2nd cervical vertebra. Line II, perpendicular to Line I, passing along the posterior border of the condyle of the mandible and the transverse processes of the vertebrae. The carotid sinus is located in front of the anterior tubercle of the 4th cervical vertebra (marked with a block dot).

(B) *Step I* The tip of the needle located on the anterior tubercle of the 4th cervical vertebra.

Step II The final position of the needle. Its tip is located slightly above and behind the carotid bifurcation.

marks the site of introduction of the needle (Figs 1 and 2A). After the superficial landmarks have been accurately determined, the area is prepared with the usual surgical antiseptic precautions. The head is then turned slightly to the opposite side without altering the position of the spine from the midline. An intradermal analgesic wheal is raised at the site of introduction of the needle.

Step I A 50-mm by 0.7-mm Labat-type needle, threaded with a rubber depth recorder which is placed 3 cm from the tip, is inserted directly perpendicular to the sagittal plane of the neck. The needle should contact the anterior tubercle of the 4th cervical vertebra no further than the depth of the recorder (Fig 2B). For the purpose of identification the operator should

be able to pass in front of the tubercle without meeting bone. To accomplish this, the rubber recorder is retracted an additional centimeter from the tip of the needle, its shaft is withdrawn for approximately 2 cm, the hub is moved slightly posteriorly and the needle is reinserted. After establishing the identity of the anterior tubercle of the 4th cervical vertebra, the needle, with the rubber recorder again set 3 cm from the tip, is reinserted to this point as originally described.

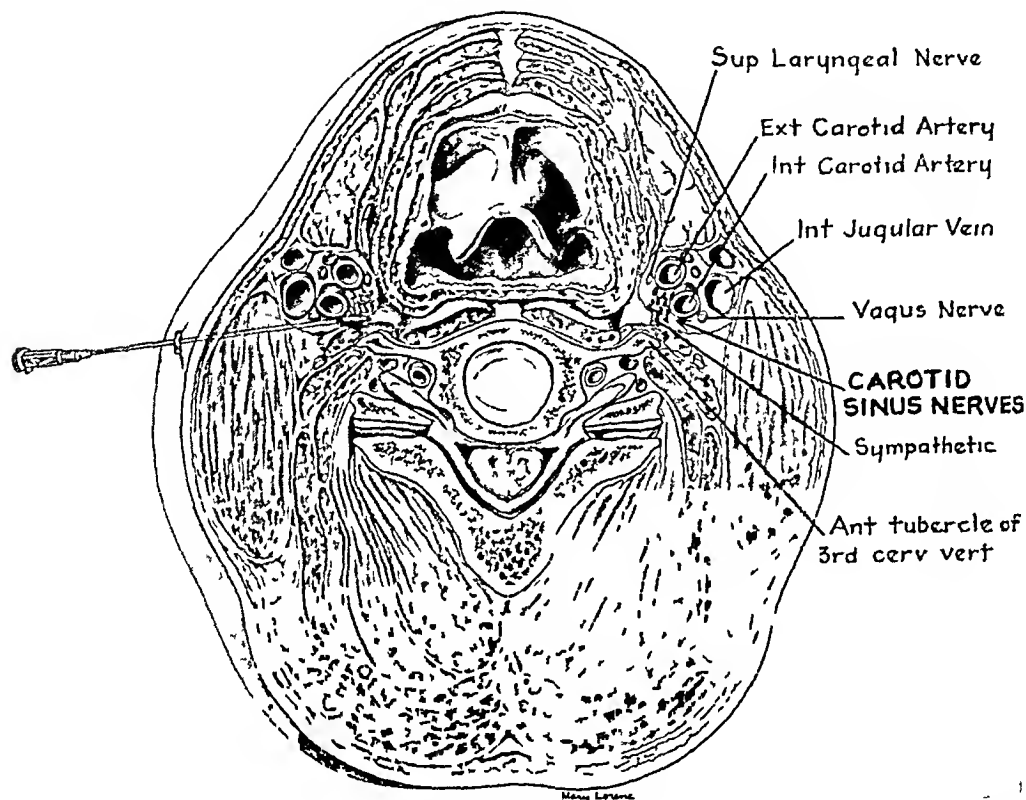


FIG 3—Cross-section through the neck at the level of the 3rd cervical vertebra, showing the relations of the structures of the neck to the penetrating needle. Its tip is located at the carotid sinus nerves slightly above and behind the carotid bifurcation.

Step II To reach the carotid sinus nerves, the rubber recorder is again withdrawn for 1 cm. The needle is then retracted until its tip lies freely in the superficial structures and the hub is moved ten degrees posteriorly and caudally. Assuming this final position, the needle is inserted to the full depth marked by the rubber recorder. The tip will then have reached the carotid sinus nerves posterior to, and slightly above, the carotid bifurcation (Fig 2B). On its route the needle penetrates the sternocleidomastoid muscle and after passing the posterior aspect of the internal jugular vein it enters the carotid sheath. The transmitted pulsation of the carotid artery will then be noted at the hub of the needle (Fig 3). In individuals with a short neck, where a higher position of the carotid bifurcation is to be expected, the hub of the needle should be depressed for 15 or 20 degrees caudally.

before the insertion, so that the tip may reach a higher level. When the needle has attained its proper position, the aspiration test is performed, so as to avoid an injection into the circulation. Five cubic centimeters of a 2 per cent solution of procaine is injected slowly. Before applying the second compression test at least ten minutes should elapse to attain a complete nerve block.

COMPLICATIONS

(1) Hypersensitivity to procaine solution, although rare, is noted by the local reaction of the skin to the raising of the intradermal wheal. If present, the test must be discontinued. (2) Injecting into the blood stream or sub-archnoidal space can be avoided by the judicious use of the aspiration test. (3) The occurrence of local hematomata can be minimized by using sharp needles. (4) Perforating the pharynx and subsequent development of infection can be avoided by strict adherence to the principles as herein described. (5) A concomitant Horner's syndrome and hoarseness due to the involvement of the cervical sympathetic and vagus nerves are of a transient nature.

Except for the occurrence of an Horner's syndrome and hoarseness in approximately 15 per cent of our series of 50 patients, none of the above mentioned complications have been observed.

SUMMARY

A technic of blocking the carotid sinus nerves necessary for the diagnosis and prognosis of an hyperactive carotid sinus reflex has been described. This technic is based on anatomic, radiologic and clinical studies.

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PANCREATIC CALCULI

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THOUGH THE INCIDENCE of pancreatic calculi is still generally considered to be quite low, the reports of the last 15-20 years indicate that this condition is much more common than is generally appreciated. The ease with which the condition can be recognized and the possibilities for relief by present-day surgical measures make it quite worth while to bear this disease in mind in the differential diagnosis of abdominal complaints.

Most reports on the incidence of pancreatic calculi as found by reviewing a series of autopsies indicate the finding of 1 in 1,500 to 3,000 cases.⁷ In reviewing a series of abdominal films the incidence was found to be 1 in 754 cases.⁷ The most significant study, however, was made by removing the pancreas in 542 cases at autopsy. The gland was then subjected to roentgenologic examination. In those which showed calcification by this method dissection was carried out. In this way 28 cases were discovered—an incidence of 1 in 20.⁴⁷

The progress in recognition of this disease can be traced through three phases. The earliest cases were discovered quite by chance at autopsy. Such cases were of necessity rather infrequent since there may be little grossly to focus attention on this organ at postmortem examination. As abdominal surgery was more widely undertaken, with the advent of anesthesia and later of asepsis, many cases of pancreatic calculi were discovered at operation. The real progress in the recognition of this disease, however, came with the use of the roentgen-ray to demonstrate the calcifications prior to operation. The earliest case to be reported was one discovered by deGraaf,⁵ in the 1660's, at postmortem examination. There were scattered reports of this sort until the turn of the 20th century. At that time abdominal surgery had opened the door for the discovery of further cases at the time of operation. In 1904, Mayo Robson¹⁸ first hypothesized the possible value of the roentgen-ray as a means for diagnosis of this disease. It was not until 1912, however, that the first case was recognized in this manner.⁴⁴ Few more were so recognized before 1925. Since then many cases have been reported—usually following roentgenologic examination of the abdomen. Prior to 1925 only 102 cases had been reported, but during the next 13 years, as interest was focused on this disease, 102 more cases were reported.²⁰ Now, there are well over 200 cases in the literature.

The etiology of this disease is not clear. While many have called attention to the biliary tract disease which is associated in some cases,³² most patients show no such associated involvement. The possibility that the pancreatic disease may be secondary to biliary tract involvement seems unlikely, therefore. The consideration of reflux of bile into the pancreatic ductal system as a causative factor also is not widely credited. The calculi are made up almost

entirely of calcium carbonate and calcium phosphate, there are occasionally minor additions of organic matter. These salts are not normal constituents of pancreatic juice. We must consider, therefore, that the primary factor in the development of pancreatic calculi is that of an alteration in the composition of the external secretion of the gland. This may result from infection from any source—blood, lymphatic or ductal. A secondary factor of stasis also probably plays a rôle, but simple ligation of the duct in an experimental animal does not uniformly produce calculi. Attacks of pancreatitis may give rise to areas of calcification in the pancreas but are not the source of most calculi. Pancreatic calculi are totally different from biliary calculi. Instead, they resemble very closely those seen in the salivary glands and ducts. They are whitish or grayish-white in color and are very hard, rough and horny in contour. They are rarely faceted even though multiple. They may vary in size from that of a grain of sand up to 2.5 inches in diameter, and may weigh as much as 200 Gm.³¹ Though solitary calculi have been found, usually there are multiple stones, up to several hundred in number. Their most common location is in the head of the pancreas, with decreasing frequency toward the tail, though in cases with multiple stones the entire gland may be studded with calculi. Some observers have distinguished two types of pancreatic lithiasis—a diffuse calcification within the gland and calcifications limited to the larger ducts only. Many of the former actually represent cases with hundreds of calculi, most of which will of necessity occupy the smallest ducts and, therefore, appear at first glance to lie within the substance of the gland itself.

Though certain small series have given conflicting reports as to sex-incidence, it is now well-established that the disease predominates in the male in the ratio of 3 or 4 to 1. The disease has been reported at the ages of 14 to 72 years, but occurs most commonly in the 4th and 5th decades.⁵³

An occasional case is asymptomatic and is discovered quite by chance. The most common symptom, however, is that of pain. This pain typically is a severe epigastric colic resembling that seen in obstruction of the cystic duct of the gallbladder. The pain is usually located more in the midline, however, and often radiates to the left upper quadrant and back and occasionally also to the left scapula and shoulder. The colic is often severe enough to require opiates for relief, although at times the pain is of a duller and more constant nature. As in biliary colic, nausea and vomiting are frequent accompaniments of pancreatic colic. Weight loss is very common and some show frank emaciation and cachexia. Many are alcoholics. This may represent an attempt to obtain release from the pain rather than a precipitating factor in the development of the calcifications. Many also present evidence of tuberculosis, this may, however, be secondary to the extensive weight loss. As a result of obstruction to the pancreatic duct by the calculi which precipitate the attack, pancreatic enzymes cannot reach the intestinal tract. This interference may lead to changes in the stools characterized by frequent, pale, frothy, bulky stools containing increased amounts of fat. Also, there is an increase in the amounts of undigested meat fibers in the stools. Many have reported making the diag-

nosis of pancreatic lithiasis by observing the passage of calculi in the stools following an attack of colic.²⁶ The calculi often become impacted in the region of the ampulla of Vater. This may lead also to obstruction of the common bile duct, therefore, jaundice has been seen in many cases of pancreatic colic. In one series,²⁰ 28 per cent presented this finding. With recurrent attacks of obstruction, the pancreas gradually undergoes atrophy and develops degeneration of the parenchyma. The first part of the gland to show this change is the acinar tissue. Only after some time are the islet cells also destroyed.

Oser⁴¹ was able to find 24 of 70 cases (34 per cent) of pancreatic calculi showing diabetes. Other authors have reported an incidence of 40 per cent or more. A transient glycosuria may occur during an attack. Many cases show a diabetic type of glucose tolerance curve even though they do not spill sugar in the urine. These alterations in sugar tolerance at first are limited to the acute attack, but as damage to the pancreas progresses, and permanent changes set in, the diabetic tendency also remains constant. An improvement in the glucose tolerance curve and a disappearance of glycosuria has often followed operative intervention for pancreatic calculi. Painful diabetes should be a warning to search for pancreatic stones. In advanced stages of degeneration of the pancreas secondary to calculi producing obstruction, fatty changes of the liver often develop, apparently the result of loss of lipocae from the destruction of the pancreas.⁴⁹ Many of these patients present multiple scars on the abdomen as evidence of misdirected and unsuccessful operations, the result of mistaken diagnoses. There is little to find specifically on physical examination of these cases. Occasionally a mass develops in the upper abdomen during an acute attack as a result of obstruction of the pancreatic duct. In some the pancreas may be outlined as a firm mass, perhaps somewhat tender. Fever, chills and leukocytosis may or may not accompany an attack. The disturbance of sugar metabolism has been discussed above. Elevation of the serum amylase and lipase and urinary diastase during an acute attack has been recorded. By intubation studies the decrease in the amount of pancreatic secretion and in the enzyme content of it has been noted. These tests, however, are not very readily performed. The determination of increased fecal fat, however, is easily carried out.

Aside from the history and the character of the pain, by far the most important diagnostic measure available is that of roentgenologic examination. This should consist of a survey film of the abdomen, including both antero-posterior and lateral or oblique views. The pancreas lies transversely in the region of the first to third lumbar vertebrae, the tail rising much higher than the head, up to the 10th to 12th dorsal vertebrae. The lateral view confirms the position of the calcifications in relation to the spinal column. Since these stones are almost pure calcium they cast a denser shadow than most biliary tract stones. However, they may also be confused with renal calculi, calcified mesenteric lymph nodes and calcified plaques in the splenic vessels or aorta. A cholecystogram and a urogram or pyelogram should aid in establishing the location of the calcifications with relation to the biliary and urinary tracts. At

times a duodenal tube has been passed to outline the course of the duodenum and, therefore, also the position of the pancreas and any calcifications within it

Many cases of pancreatic calculi have been missed because a barium meal has been given before any films were taken. The overlying stomach and intestinal shadows then obliterate most pancreatic calculi, though some may be seen above the lesser curvature of the stomach. Fluoroscopic examination alone may readily miss these stones, so all gastro-intestinal series should include a preliminary survey film before giving the barium meal.

Complications of pancreatic calculi—aside from the effects produced by interference with enzyme and hormone production—include the development of cysts, abscesses, carcinoma and hemorrhage. The cysts may vary in size with acute attacks. The abscesses may present on the abdominal wall or rupture spontaneously into surrounding viscera. Occasionally a stone has eroded into a vessel large enough to give rise to severe or even fatal hemorrhage into the gastro-intestinal tract.¹⁵ A small percentage of cases show malignant change, but this does not necessarily bear any relation to the presence of the calculi.

The first case to be treated surgically was in 1876,²⁰ when a pancreatic abscess containing calculi was drained. The first successful removal of a pancreatic calculus was by Moynihan,²⁰ in 1902. There were very few cases treated surgically prior to 1920. Since then, this problem has been attacked with increasing frequency, and with very encouraging results. The recent operative procedures developed for resection of the pancreas for carcinoma have added confidence in attacking this organ. It is recognized that such cases can be done without the development of fat necrosis or fistulae.

The approach to the pancreas may be through the gastrohepatic or gastrocolic omentum or through the transverse mesocolon. The latter seems less desirable, and the integrity of the middle colic vessels must be carefully preserved. We feel that a transverse incision gives ideal exposure for easy visualization of the entire gland. The pancreas may be enlarged, normal in size or atrophic, depending on the stage of the disease. It is likely to be quite firm and rubbery, and has the appearance of an ear of corn (interlobar pancreatitis). The calculi often can be felt, giving a sense of crepitus as they are rubbed one against another. By dividing the pancreas the duct can be exposed. This is usually dilated and the stones can be removed through it. It may be necessary to divide the duct longitudinally in order to obtain adequate exposure. If the stones are multiple and diffusely scattered throughout the pancreas, subtotal resection, beginning at the tail, is the most satisfactory procedure. One should be able to pass a catheter into the duodenum at the conclusion of the dissection. Though we have never tried such a procedure, the injection of lipiodol through the catheter to outline the ductal system while the patient is still on the table might occasionally be of value in confirming the patency of the duct or demonstrating other calculi. The stones often become impacted as the duct passes through the duodenal wall, and it may be of value to mobilize the duodenum by dividing the lateral peritoneal reflection and,

thereby, expose the head of the pancreas better. Some have opened the duodenum in order to free a stone trapped at the ampulla of Vater. A catheter left in the pancreatic duct and cigarette drains in the lesser peritoneal cavity provide adequate drainage. No permanent fistulae have developed. The pancreatic fluid which escapes from the wound is almost entirely nonirritant to the skin. This is in striking contrast to that from duodenal fistulae and many biliary fistulae in which the pancreatic enzymes have been activated.

The over-all mortality for operative treatment of pancreatic calculi is about 18 per cent, though smaller series have obtained figures of 8 per cent, and less. The results have been very encouraging and surgery is now the treatment of choice for this condition in severe cases. In milder cases a diet low in carbohydrates and high in proteins and fat may decrease the demands on the pancreas to produce secretion and, therefore, diminish the severity and frequency of the attacks. Ephedrine sulfate gr $\frac{3}{8}$ during an attack is of value by decreasing the amount of pancreatic secretion. This drug may also be used in conjunction with the diet as a prophylactic measure.

During a 10-year period, from 1936 to 1945 nine cases of pancreatic calculi were admitted to the services of the senior author at three hospitals. All were explored. There was one death in this series, a mortality of 11 per cent. Of the remainder, only one was not definitely improved though some continued to have slight residual symptoms. A brief summary of these cases follows.

CASE REPORTS

Case 1—T McG (25092) A 38-year-old white male was admitted because of weight loss, severe epigastric colic, and diarrhea for six years. He showed steatorrhea, glycosuria and hyperglycemia. Roentgenograms revealed many pancreatic calculi. These were removed. His diarrhea disappeared, his insulin requirement dropped from 40 to 15 units. Though he subsequently took raw pancreas for a time he has since found that unnecessary, and now is entirely asymptomatic.

Case 2—R M (48644) Admitted because of acute upper abdominal pain. Studies revealed a pancreatic calculus. There was no glycosuria. The stone could not be located at exploration. The duct was not opened, however. She had no postoperative pain.

Case 3—F E (59445) A 49-year-old white man was admitted because of recurrent attacks of severe epigastric pain for eight years. Roentgenograms showed several pancreatic calculi. There was no glycosuria. Several stones were removed from the dilated duct. He has obtained marked relief from operation.

Case 4—E S (59784) A 46-year-old white man was admitted because of epigastric discomfort, anorexia and weight loss. An epigastric mass was previously drained elsewhere as a pancreatic cyst. At operation here, partial pancreatectomy was done, with removal of several stones from the head of the pancreas. He was well for six weeks and then developed recurrence of pain and marked diabetes eventually. A more extensive pancreatectomy was performed and further stones removed. He did not recover from the operation.

Case 5—E S (63562) A 43-year-old white woman was admitted because of recurrent attacks of severe upper abdominal pain and weight loss. Roentgenograms showed pancreatic calculi. Partial pancreatectomy and removal of calculi was done. After four months the drainage tract was reopened, but subsequently closed again. She has been much improved. She has been much improved.

One year after operation she developed weight loss associated with a diarrhea of 10

PANCREATIC CALCULI

to 20 movements a day. On vitamin therapy and pancreatic extract, the diarrhea was controlled, she regained her weight and has an excellent appetite.

Case 6—E D (63983) A 40-year-old white woman was admitted because of acute pancreatitis. A survey film showed several pancreatic calculi. At operation, several areas of frank hemorrhagic necrosis were found and drained. The pancreas sloughed-out in part. Subsequent films showed disappearance of calculi. The patient has had no further symptoms.

Case 7—C S, a 65-year-old white man was admitted because of recurrent epigastric colic. A nonfunctioning gallbladder and several pancreatic calculi were shown roentgenographically. Cholecystostomy was done and several gallstones removed, also one pancreatic calculus.

Case 8—V B (125) A 52-year-old white woman was admitted because of abdominal pain, nausea, vomiting and weight loss for several years. Roentgenograms showed pancreatic calculi, several of which were removed at operation. She has continued to have pain since then and uses opiates. This patient was a morphine addict, with several hospital admissions before her diagnosis was finally made.

Case 9.—J S, a 57-year-old white man was admitted because of acute upper right quadrant abdominal pain, subsequently diagnosed acute cholecystitis. Celiotomy did not relieve him. He was later operated upon for intestinal adhesions, without relief. On his third admission, when his roentgenograms were reviewed, shadows of pancreatic calculi were noted. At operation, a dozen stones and two-thirds of his pancreas were removed. A fistula presented when the drain was removed. The fluid discharge was clear and did not irritate the skin—the usual state of affairs if no bile is mixed with the pancreatic fluid. Recovered. An incidental finding was a gumma of the spleen.

Sixty-six cases from the literature were reviewed, and from these the data in Table I were compiled.

TABLE I

	No	Percent
Average age	43	
Sex		
Male	44	67
Female	22	33
Duration of symptoms (average)	7 yrs	
Pain	55	83
Colic	35	53
Nausea	32	49
Vomiting	29	44
Diarrhea	15	23
Fatty stools	13	20
Jaundice	10	15
Alcoholics	17	26
Weight loss	33	50
Tuberculosis	5	8
Diabetes	33	50
Carcinoma	3	5
Solitary calculus	6	9
Gallstones	7	10
Preoperative roentgenographic diagnosis	34	52
Shadows seen above lesser curvature of stomach	7	10

SUMMARY

- (1) Pancreatic calculi occur much more commonly than is generally appreciated.
- (2) They can readily be recognized by roentgenologic examination.
- (3) Surgical relief can be obtained, and this is the procedure of choice in severe cases.

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NOTE Since this article was submitted for publication, other papers have appeared which are not included in the bibliography above We would like to call attention especially to the paper, "Radical Surgery for Certain Cases of Pancreatic Fibrosis Associated with Calcareous Deposits" by Allen O Whipple, in the *ANNALS OF SURGERY*, vol 124 991-1008, December, 1946

CYSTADENOMA OF THE PANCREAS

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CYSTADENOMA OF THE PANCREAS is an uncommon lesion. In a review of 6,708 autopsies at Guy's Hospital, in 1897, White found only three cases of pancreatic cyst, none of which was cystadenoma. Fitz, reporting a case, in 1900, commented upon the uncommonness of the lesion. From most reports since, its infrequency can be inferred, and Slattery, Boyd, Neef, Rabinovitch and Pines, and Brunschwig make specific reference to the rarity of the lesion.

The actual frequency of occurrence of pancreatic cystadenoma is difficult to estimate because cases are buried in the literature in general discussions of diseases of, or surgery of, the pancreas, and many cases of multilocular cyst of the pancreas of other varieties are undoubtedly falsely included as cystadenoma through inadequate pathologic study, misinterpretation, or unsatisfactory material. Mahorner and Mattson point this out stating that multilocular cysts are not necessarily cystadenomata, and that the meager descriptions so often found in the literature make it difficult to accept many cases as such. Hence, we get varying reports of the incidence of the lesion. Thus, Gruber quotes Yamane as having collected 37 cases up to 1921, while Hueper, in a report of one case, in 1928, states that only 24 cases had been recorded in the literature up to that time. Subsequent to 1928, only individual cases and small series are found in the literature. One case was reported by Maes in 1931, two cases by Janes, one by Carter and Slattery, and one by Pettinari in 1936, one by Neef in 1939, five by Bowers, Lord and McSwain (of which one was unproved), and two by Rabinovitch and Pines in 1942, and one by Beloff in 1945. In 1942, Brunschwig reported four cases from the University of Chicago Clinics and estimated that there were about 50 cases to that date.

Another approach to the frequency of occurrence of cystadenoma of the pancreas is through the incidence of the lesion in studies of large series of autopsies, operative cases, or hospital admissions. Here, again, a wide variance is found. Priesel, in 1922, reported that he had found nine cases in a review of 9,000 autopsies. Adams and Nishijima, in 1946, reported that the diagnosis of pancreatic cyst had been made at the Lahey Clinic only nine times from 1926 to 1945, and none of these were cases of cystadenoma. In 1921, Judd reported 41 cases of pancreatic cysts of all varieties gleaned from the records of the Mayo Clinic up to that date. The incidence of cystadenoma, or of the various other types of pancreatic cyst, is not given as it was impossible because of the degree of tissue destruction in many cases to tell whether they were dealing with a true or pseudocyst, or if a true cyst, what its exact nature was. In 1931, Judd, in conjunction with Mattson and Mahorner, published a second report on 47 cases of pancreatic cyst operated upon in the interval, the total of 88 cases having been obtained from 723,397 patients seen at the Mayo

Clinic in the corresponding period. No figures are given in this paper for the frequency of occurrence of the various types of pancreatic cyst but in another paper, later in the same year, Mattson and Mahorner state that two cases of cystadenoma were found in 108 cases of pancreatic cyst, which included these 88 and 20 others found at necropsy. Walters and Cleveland, in a report in 1939, state that 22 patients with pancreatic cyst were operated upon at the Clinic between 1935 and 1939. Thigpen, who analyzed the data on pancreatic cyst for a University of Minnesota Graduate School Thesis, is then quoted to the effect that from 1908 to 1939, 139 patients with pancreatic cyst were treated surgically at the Clinic, or one for every 8,000 patients registered. Of 55 of the 139 cases in which adequate tissue was available for study, seven were cystadenomata. In a later article, in 1945, Walters and Clagett repeat the previously-stated incidence of pancreatic cyst as one in 8,000 patients registered, with two cystadenomata in 88 cases of pancreatic cyst. While this probably does not exhaust the literature, it is sufficient to indicate the impossibility of arriving at any definite knowledge of the actual incidence or total number of cases reported. However, the uncommonness of the lesion is indicated with sufficient unanimity to warrant both the report of an additional case and a discussion of the special features characterizing cystadenoma of the pancreas.

All authors seem to agree that cystadenomata of the pancreas are true proliferative tumors. Robson and Moynihan classify pancreatic cysts as retention cysts, proliferative cysts, congenital cystic disease, hydatid cysts and pseudocysts. Proliferative cysts include cystadenomata and cystic epitheliomata. Boyd's classification omits hydatid and hemorrhagic cysts, but is otherwise essentially the same. McWhorter (after Oser) develops a detailed classification on the same fundamental structure, including cystadenomata among the cystic neoplasms or proliferative cysts. Brunschwig omits cystadenoma and cystadenocarcinoma from his classification of pancreatic cysts, preferring to consider them in a separate category of true neoplasms. Other minor variations are found consisting essentially of the addition of individual pathologic types, such as dermoid cyst by Judd, inclusion cyst by Rabinovitch and Pines, cyst with carcinomatous degeneration by Kennard, and cystic hemangio-endothelioma, cystadenocarcinoma of the islets of Langerhans, cavernous hemangioma, sebaceous cyst, and cyst of an accessory pancreas, by Walters and Cleveland. The basic classification, however, remains unchanged, with the general acceptance of cystadenoma as a true tumor or new growth similar to corresponding tumors of the ovary. A representative classification that is both inclusive, and simple, is that of Walters and Clagett. On an etiologic basis they classify pancreatic cysts as

1. Cysts resulting from defective development

- (a) Cysts among infants
- (b) Cysts associated with polycystic disease of the kidney
- (c) Dermoid cysts
- (d) Inclusion cysts

- 2 Cysts resulting from trauma (pseudocysts)
- 3 Retention cysts
- 4 Neoplastic cysts
 - (a) Cystadenoma
 - (b) Cystadenocarcinoma
 - (c) Teratomatous cysts
- 5 Cysts resulting from parasites

While it is agreed that the tumors are true neoplasms arising from a disturbance in ontogeny, the exact locus of the disturbance remains obscure. Priesel believes that the tumors arise by the proliferation of the cylindrical epithelium of the pancreatic ducts, such proliferation going on to the formation of cystadenomata, or even adenocarcinoma. He adds that most authors believe that cystadenomata of the pancreas are due to aberrant pancreatic tissue which has become isolated. Lazarus describes many stages in development from simple dilated ducts. Archibald describes them as true tumors arising from parenchymal cells by proliferation. Rabinovitch and Pines also refer to cystadenomata as true pancreatic tumors arising from the parenchyma. Judd states that they form as do the cystadenomata of the thyroid or ovary, they are papillary ingrowths or adenomatous cysts. Gruber raises the question of duct proliferation on an inflammatory basis but it is generally agreed that this is not the case with cystadenomata. It is also suggested that the tumors originate from primordial cells displaced in early embryonic life, but opinions vary as to which embryonic tissue is involved. Displaced cells of the primitive urogenital fold having their origin from the segmentation cells of fetal life (the strayed genital cell theory), remnants of the mesonephros, and abnormal budding-off from the primitive gut have all been proposed as the original source. Carter and Slattery discuss the various embryonic sources hypothesized, and conclude that the type of tumor with cells closely resembling pancreatic tissue probably originates from displaced alimentary canal primordia while cystadenomata with no resemblance to pancreatic tissue probably arise from strayed genital cells of the urogenital fold or from remnants of the mesonephros.

Grossly, the cysts vary in size and external and internal appearance. Ordinarily, cystadenomata do not reach the large size frequently encountered in other types of pancreatic cyst, although quite large ones have been reported. Fitz' case, for instance, was the size of a squash, Pringle's the size of a football, Beloff's the size of a grapefruit, Kennard's 15 cm, Dragstedt's (included by Brunschwig) 15 cm, and two of Bowers' cases were 15 and 18 cm, respectively, in their longest diameters. Characteristically, cystadenomata are rounded tumor masses with coarsely lobulated surfaces, although the larger ones are occasionally smooth-walled. Brunschwig speaks of their resemblance to a dense cluster of grapes. Encapsulation may be complete, although, as in our case, the cyst may be demarcated from the surrounding tissue without definite encapsulation. On section, they are almost always multilocular. The locules, or cyst spaces, are usually quite numerous, and may have a honeycomb appearance. They vary greatly in size, from less than a centimeter to as much

as 8 cm, but are inclined to be small. The contents of the cysts vary from thin, clear, turbid, or hemorrhagic fluid to viscid, mucoid or gelatinous material. The fibrous stroma between the locules may be scarce or abundant. Broad bands of hyalinized connective tissue, resembling the corpora albicans of the ovary, may be present, and in our case there was a central mass of fibrous tissue in which calcium had been deposited.

Microscopically, the cysts are lined, characteristically, by a single layer of epithelium. The cells may be cylindrical, like those of the pancreatic ducts, but more frequently are cuboidal or flattened. The flattening may even be more extreme so that the cells resemble endothelial cells to a degree that may lead to some doubt as to whether the tumor may not be a lymphangioma or hemangioma. Bloodgood, describing the histology in Finney's case, states that MacCallum, who also examined the slides, thought the tumor to be a lymphangioma, and one pathologist, reviewing the slides of the case reported here, was struck by the resemblance of the microscopic picture to that of hemangioma.

The cytoplasm of the cells is clear, the nuclei basal. The epithelial lining may be thrown into papillary projections or may dip down into the wall of the cyst in the form of a gland. In almost all cases, however, the single epithelial layer is maintained, although the heaped-up epithelium in the papillary folds may seem to show several layers. The presence of several layers may, according to Gruber, be an indication of malignancy. However, in Neef's case, about 3 per cent of the cyst cavities showed an epithelial lining 2 to 5 cells deep. In many cases the arrangement is similar to that of cystadenoma of the ovary, or even of the breast, and Bloodgood remarked on the resemblance of Finney's case to a breast cystadenoma. The stroma between the cyst walls is of variable thickness and may consist of a thin layer of loose bands of connective tissue or of broad, dense, hyalinized connective tissue septa which in our case contained bony spicules. The surrounding uninvolved pancreatic tissue is usually normal. In Pettinari's case there was an associated acute pancreatitis for which operation was performed, but Pettinari felt that there was no casual relationship.

It is important to point out that the differentiation between cystadenoma and other varieties of multilocular cyst of the pancreas (retention cyst) cannot always be easily made and sometimes may be impossible to make. Brunswick emphasizes this point and other authors make it by inference. Usually, the cyst spaces in cystadenoma are multitudinous and small, with or without a few large ones, while those of multilocular cysts are relatively few and larger. Also, the cysts as a whole are usually larger than cystadenomata. The epithelial lining may be similar in both but its absence in large locules favors the diagnosis of multilocular cyst.

Malignant forms are much more rare than the benign ones. In distinction to papillary cystadenoma of the ovary, Kennard feels that malignant proliferation of a benign cystadenoma of the pancreas is rare. However, malignant change does occur, and Lichtenstein states that he feels justified in assuming

that his case of papillary cystadenocarcinoma started as a benign cystadenoma as the patient was known to have had the mass for six years and during that period was free of both symptoms and anemia, in addition to which, microscopy after its removal showed portions of the tumor with the structure of benign cystadenoma without any evidence of cellular atypism. Maes' case of benign cystadenoma showed occasional areas in which an infiltrative tendency was apparent, and one of Brunschwig's cases, in which the microscopy showed a benign cystadenoma, grossly infiltrated the duodenum requiring pancreaticoduodenectomy. Fitz called his tumor a multilocular cystadenoma but thought it was on the borderline between proliferative cystoma or cystadenoma, and cystomatous carcinoma. Carter and Slattery express the opinion that cystadenoma may give rise to cystadeno-carcinoma and that the pathology in some cases may be borderline.

The most common site of pancreatic cystadenoma, according to Heiberg, Robson and Cammidge, and Walters and Cleveland, is in the tail. Conversely, Lazarus states that the rarest site is the head of the pancreas. Again, it is difficult to compile accurate figures, but in the available literature only a few cystadenomata of the head are found while the remainder, comprising the vast majority of the tumors, seem to be about equally divided between the body and tail.

In growing, the cysts usually present between the stomach above and the colon below, covered anteriorly by the gastrocolic omentum. Occasionally, they present above the stomach in which case the anterior covering is the gastrohepatic omentum. Rarely, the direction of growth is between the layers of the transverse mesocolon with the cysts presenting behind or below the colon, or, they may extend upward or downward retroperitoneally.

Cystadenoma of the pancreas is much more common in females than in males. The symptomatology is that which one would expect of a slowly expanding lesion arising from the pancreas and is of course the same as that of any variety of pancreatic cyst. Pain is the most common subjective symptom. The location of the pain will vary with the location of the cyst and the structures upon which it impinges. Obviously, a cyst may be "silent" for a considerable period. When pain is experienced it may occur in any quadrant of the abdomen although usually it is in the upper abdomen and most often in the left upper quadrant. Occasionally it is referred to the back. The quality of the pain varies from a sense of fullness or a dull ache to severe relatively steady pain or sharp abdominal cramps. Radiating abdominal pains from pressure upon the celiac ganglion have also been described. Other symptoms result from pressure upon the neighboring organs, especially the stomach, and include anorexia and epigastric discomfort after meals, or nausea, vomiting, belching, gaseous distention, and constipation. Frequently these may be the only symptoms. Slight jaundice was encountered only once, in one of Janes' cases, the rarity being due to the rareness of the location of cystadenomata in the head of the pancreas. Weakness and weight loss are occasionally seen due to interference with nutrition, or uncommonly, to malignant degeneration.

The only significant physical finding is a palpable mass which in those of large size the patient may have noted himself. The mass is usually in the upper abdomen, in most instances to the left of the midline. In the large cysts it is likely to be tense and smooth, possibly cystic to palpation. The smaller ones usually cannot be palpated with sufficient definition to determine their characteristics. When arising from the body of the pancreas the mass is usually immobile. If the site of origin is the tail it may be freely movable, and occasionally, as in the case reported here, there may be considerable mobility when it arises from the head. Fluctuation can occasionally be demonstrated in the larger tumors. Laboratory data is of little assistance unless the external secretion of the pancreas is interfered with, in which case there will be an increase in fat, starch, and muscle fibers in the stools.

Roentgenograms are frequently of great assistance in diagnosis. The presence of a compression defect in the stomach, duodenum or transverse colon, an enlarged duodenal loop, or the displacement of the viscera, offers additional presumptive evidence when added to the other diagnostic data. The deposition of calcium in the cyst wall may, in rare instances, make it visible in the roentgenogram. Pneumoperitoneum and intravenous pyelography offer further aid.

Pancreatic cyst must be differentiated from mesenteric cyst, which usually has greater mobility particularly in a transverse direction and is generally prominent in the region of the umbilicus, from omental cyst which is usually very mobile and situated lower in the abdomen, and from ovarian cyst, hydatid cyst of the liver, fluid tumors of the kidney, giant hydrops of the gallbladder, retroperitoneal cysts, cysts of the posterior gastric wall or spleen, aneurysm of the abdominal aorta, and abscess of the pancreas. The differentiation of cystadenoma of the pancreas from other types of pancreatic cyst cannot usually be made clinically, and frequently the diagnosis of pancreatic cyst itself can only be made through surgical exploration.

Treatment, wherever possible should consist of surgical extirpation. This cannot always be effected because of the intimate relation of the cyst to important surrounding structures which would make their injury inevitable. The portal vein, common bile duct, splenic vessels, and superior mesenteric vessels may be intimately adherent to the cyst rendering its removal unduly hazardous. Serious hemorrhage may also be encountered, and Whipple states that one should be certain before attempting removal that it can be accomplished as otherwise serious damage may result. Nevertheless, with modern advances in surgery the operability has been considerably broadened. An excellent operative review is given by Brunschwig. Whenever feasible, he advocates incision through pancreatic tissue just beyond the gross limits of the bulging tumor surface with an effort to establish a cleavage plane. The tumor may then come away almost as though by enucleation. In Carter and Slaterry's case the junction of the cyst to the surrounding pancreas was so dense that a cleavage plane could not be established and the cyst was removed by subcapsular dissection. Large cystadenomata of the midportion of the body

of the gland replacing all or most of the thickness of the pancreas should be excised by transection and ligation of the body of the gland to the right of the tumor which is removed together with the uninvolved pancreas distal to it. There should be no hesitancy about performing splenectomy where necessary. Nothing is accomplished by leaving a small uninvolved portion of the tail, as carbohydrate metabolism can be adequately maintained when only the head remains. Cystadenomata of the head should be excised leaving as much of the neck and body as possible. Even when deeply embedded, excision through normal parenchyma should be attempted. Injuries to the common bile duct and main pancreatic duct can be repaired if they occur. Rarely, partial resection of the duodenum may be necessary and radical pancreaticoduodenectomy can be considered as a final recourse.

Marsupialization, a common method of surgical treatment in other varieties of pancreatic cyst, is not a method of choice in the characteristic cystadenoma because of the numerous noncommunicating small cysts which would render treatment by this method inefficacious. In the occasional case it may be applicable, but even in these it has not been entirely satisfactory because of the persistence of external drainage for prolonged periods and occasional additional complications, such as infection of the sinus and cyst, formation of a secondary abscess, and excoriation of the skin by the drainage. Methods to eradicate the fistula and the lining of the cyst have, on the whole, been unsuccessful.

Internal drainage, by anastomosing the cyst to the stomach, duodenum, jejunum, or gallbladder eliminates the objection of fistula formation, but is subject to the same inapplicability as marsupialization in the average case of cystadenoma. Adams and Nishijima recommend cystojejunostomy which they performed with satisfactory results in two cases of pancreatic cyst, but both the external and internal drainage methods are clearly more suitable for types of pancreatic cyst other than cystadenoma, not only because of the common multilocular architecture of the latter which would render drainage methods ineffectual but also because of the occasional malignant alteration which occurs. Accordingly, every effort should be made to extirpate cystadenomata completely. Irradiation, as far as is known, is without benefit.

The prognosis with complete extirpation should be good. Without surgery, growth may be so slow that no symptoms may develop for many years. However, with more rapid growth, symptoms of marked mechanical disturbance may occur, and the possibility of local infiltration into neighboring organs and of malignant change must be kept in mind.

Case Report—No 66173, Doctors Hospital. Mrs I B, age 31, a private patient of Doctor Samuels, was admitted January 16, 1946, for surgical exploration. She had been studied thoroughly prior to admission. About one year previously she had had occasional lower abdominal cramps which lasted for short intervals for about two weeks and then subsided. In November, 1945, she again developed occasional lower abdominal cramps which became more persistent and more severe. They usually occurred after the evening meal, but also sometimes during the day, starting in the midepigastrium as dull cramps and radiating across the lower abdomen, usually most marked in the left

lower quadrant There was no relation of these pains to bowel movements, which were regular and without bleeding Sometimes they were accompanied or followed by slight nausea, but there was no vomiting Relief was usually obtained by lying down or hot drinks Moderate relief was also afforded by antispasmodic and sedative medication The appetite was excellent, the digestion good and there were no night symptoms, specific periodicity or relief by food The cramps were also unrelated to menses or urination Fifteen pounds in about two months were lost on a reducing diet, but on discontinuation of the diet several pounds were readily regained Some fatigue was also present for the same period but this was blamed upon worry, and the care required by her two young children Her sleep was undisturbed but inadequate The remaining history was noncontributory

Physical Examination—This revealed a well-developed and well-nourished young female, appearing in good health In the midepigastrium a slightly tender, slightly irregular, firm mass, about the size of a tangerine, was palpable The mass was intra-abdominal, and freely movable, particularly from side-to-side It moved with respiration, and could be made to disappear under either costal margin The aortic pulsations were transmitted through it The physical examination was otherwise negative except for a small fibroid in the right horn of the uterus and some scarring of the left parametrium

Laboratory Data—The blood count and sedimentation time were normal, the urine, stool and blood Kahn negative The Rehfuess test meal showed an anacidity, but there was a positive response to histamine—excluding a true achlorhydria The electrocardiogram showed low voltage in Lead I and late inversion of the T-wave in Lead IV, the observed changes being considered of no significance Fluoroscopy of the stomach and duodenum showed a J-shaped, ptosed stomach completely visualized just to the left of the midline The mass was felt to be to the right of and above the duodenal bulb but the duodenal bulb filled completely and the stomach showed normal peristalsis and antrum formation There were no signs of pressure upon the antrum or duodenum Barium enema showed a normal colon and terminal ileum A plain film of the abdomen showed both kidneys of normal size, shape, and position, and no evidence of biliary or urinary calculi

Because of the marked mobility, and the absence of significant roentgenologic findings, mesenteric or omental tumor, or pedunculated extrinsic lesion of the stomach were the diagnoses that were entertained

Operation—The patient was explored, January 17, 1946, through a right epigastric paramedian muscle-splitting incision (Doctor Jemerin) The mass was seen to occupy the head of the pancreas within the curve of the duodenum, the free mobility noted on examination being due to an unusually movable duodenum and pancreas The mobility was so great that the duodenum could not only be reflected far medially leaving the mass to the right of it, but both duodenum and pancreatic mass could almost be delivered into the mouth of the wound Both the paraduodenal peritoneum and the gastrohepatic omentum were incised, completely mobilizing the duodenum and exposing the head of the pancreas The mass was then seen to occupy almost the entire head of the pancreas, only a thin rim of pancreatic tissue being identifiable as such on its posterior aspect There was no definite capsule although the mass seemed circumscribed The common bile duct, portal vein, and hepatic artery, which were identified in the free edge of the lesser omentum seemed to disappear into the posterior surface of the mass It did not seem at first as though the mass were resectable without injury to the common duct, portal vein or hepatic artery and a radical resection of the head of the pancreas and duodenum was considered However, it was decided first to make an effort to dissect the mass free, because of the high mortality and morbidity associated with radical pancreatoduodenal resection Accordingly, the common bile duct was again approached and freed up to the point where it seemed to disappear into the mass Dissection revealed it to be flattened-out and closely applied to the posterior surface of the mass, or rather shell of pancreas, bound to it by areolar and fibrous tissue, and with further dissection its

separation was effected and its entrance into the duodenum seen. In similar fashion, the portal vein and hepatic artery were liberated from the tumor. With these out of the way, the tumor itself could be safely attacked. While there was no definite capsule, a zone of demarcation from the shell of the pancreas could be identified, and this was developed by sharp dissection until removal of the entire tumor was effected. The structures of the hepatic trinity were seen to be uninjured upon completion of the resection. Some oozing was encountered from the bared surface of shell of pancreas and this was controlled by a running catgut suture. Drainage was established down to the head of the pancreas through a stab counter incision in the right flank. The wound was closed in layers.



FIG 1—Gross specimen

The postoperative course was entirely uneventful. Shortening of the drain was begun on the 3rd postoperative day and complete removal was effected by the 5th day. The patient was discharged from the hospital in excellent condition on the 8th day after operation.

The patient has been followed to date. She has no complaints, and her general condition is excellent. Physical examination shows a well-healed, soft, pliable scar. The abdomen is soft and nontender, and there are no masses palpable. Fluoroscopy shows the duodenum to have returned to its normal position to the right of the midline.

Pathologic Report—The tumor, in the gross (Fig 1), was a firm, globular, nodular mass, about 10 cm in diameter, the nodular surface being due to numerous small cysts presenting externally. On cut-section (Fig 2) multiple small cysts separated by a dense stroma of variable width were seen. The cysts averaged between 0.25 and 1.0 cm

CYSTADENOMA OF PANCREAS

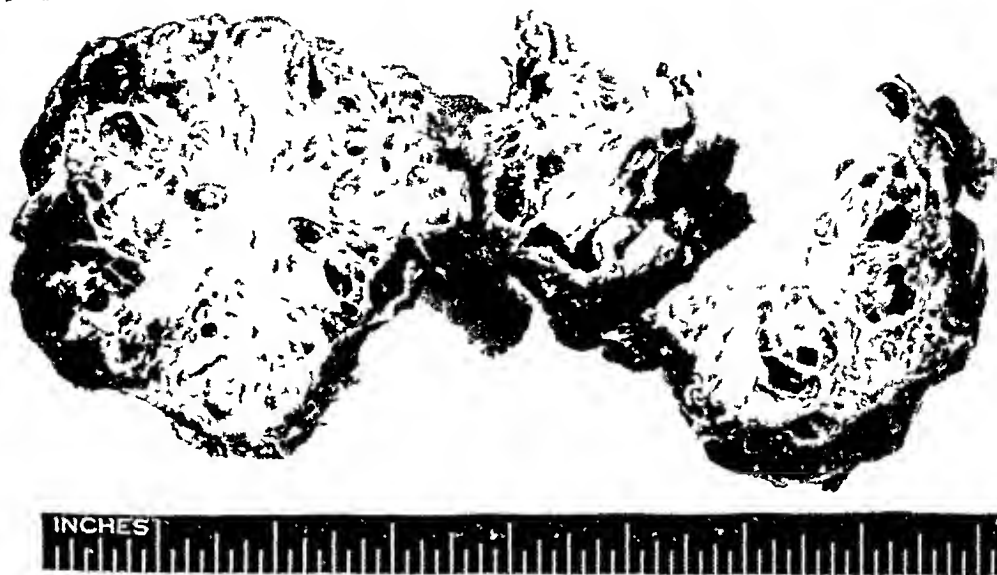


FIG 2—Gross specimen, cut-section



FIG 3—Photomicrograph (x4)

in size and were most numerous toward the periphery where a honeycomb appearance was suggested. The stroma increased irregularly toward the center of the growth, forming there a large solid central mass containing calcific deposits. The surface cysts were thin-walled and translucent, the deeper ones were embedded in increasing amounts of supporting tissue. Some contained gelatinous material, others bloody fluid.

Microscopically (Figs 3 and 4), the main portion of the mass consisted of large channels (cysts) containing amorphous material or well-formed blood cells and some hemosiderin-bearing phagocytes. The cysts were lined by a single layer of epithelial cells.

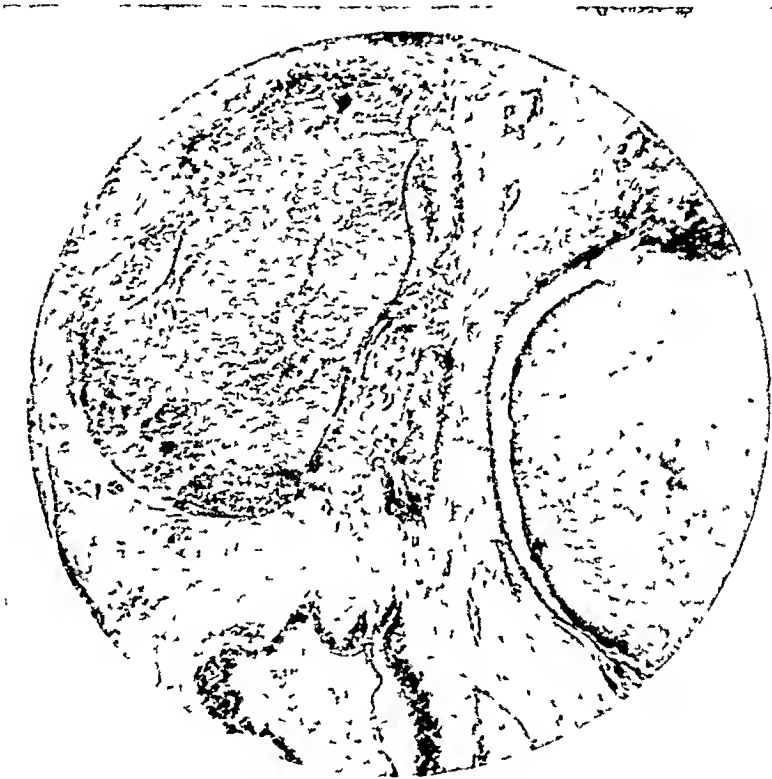


FIG 4—Photomicrograph ($\times 20$)

which ranged from cuboidal to flat. The latter resembled endothelial cells to such a degree that, just as did MacCallum in Finney's case, one pathologist reviewing these slides was highly impressed by the similarity of the histologic picture to that of an endothelial tumor. The separating stroma consisted of dense hyaline connective tissue septa of varying width and rather cellular character. Small nests of hemosiderin-bearing cells were found within the connective tissue septa. The calcified area consisted of very dense hyaline tissue with fine bony spicules. At one periphery a small portion of pancreatic tissue was seen. *Pathologic Diagnosis* Cystadenoma of the pancreas.

COMMENT—A cystadenoma of the head of the pancreas which had compressed the residual tissue of the head into a thin shell intimately applied to its posterior aspect was successfully removed. The common bile duct, portal vein and hepatic artery which were flattened out and bound to the posterior aspect of the mass were dissected free. Of note was the absence of any evidence of common duct or portal vein obstruction despite the marked compression of these structures. The location of this tumor in the head of the

pancreas is uncommon in a lesion which in itself is infrequent. The mass was markedly mobile and because of this and the absence of any suggestive roentgenologic findings, a pre-operative diagnosis of pancreatic cyst was not made. The mobility was due to an unusually displaceable duodenum and pancreatic head. It was noted, fluoroscopically, that the duodenum was situated to the left of the midline but as there was no evidence of its compression or distortion, the significance of the finding was not interpreted as suggesting a pancreatic lesion. The tumor itself was firm rather than cystic to palpation, and on section there was a considerable fibrous stroma between the numerous small cysts with a large, central solid mass containing calcific deposits. The epithelium lining the cysts in some areas bore a marked resemblance to endothelium. It is interesting that despite this presence of calcium in the mass no shadow was cast on the roentgenograms even when the films were reviewed in retrospect.

SUMMARY

1 The literature on cystadenoma of the pancreas is reviewed, and the various clinical, pathologic and surgical features of the lesion are briefly discussed.

2 A case of cystadenoma of the head of the pancreas in a 31-year-old female, with successful surgical extirpation, is reported.

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MUCOCELE OF THE APPENDIX, WITH MYXOGLOBULOSIS*

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MYXOGLOBULOSIS is a special type of mucocele characterized by the presence of globoid bodies, 2-3 mm in diameter, composed of mucoid material. They form clusters resembling frog eggs, which has led to the adoption of such names as "fish-egg or frog-egg mucocele."

The first case of mucocele with myxoglobulosis was described by Latham¹⁰ (1897), who discovered the condition by chance in the course of a routine postmortem examination. Huettei⁸ (1907) presented a case of pseudomyxoma peritonei which originated from a myxoglobulosis of the appendix. Boeckmann¹ (1910), found a mucocele of the appendix with myxoglobulosis while operating for what appeared to be acute appendicitis. Von Hansemann⁶ (1914) found this condition in two routine autopsies and gave it the name, "myxoglobulosis." Since that time a number of other cases have been reported. In 1941, Hollstrom⁷ reviewed the literature and found 36 cases of mucocele of the appendix associated with myxoglobulosis. Since then only two other cases have been mentioned in the available literature. As to the frequency of ordinary mucocele and myxoglobulosis, only a few data are available. Neither in Castle's⁴ 28 cases of cystic dilatation of the appendix, nor in Jirka and Scuderi's⁹ 22 mucocèles found in 9,535 appendectomies at Cook County Hospital, Chicago, nor in Mayo and Fauser's¹¹ 76 mucocèles, was any mention made of the presence of myxoglobulosis. In 1925, Milliken and Poindexter¹² stated that the incidence of myxoglobulosis in cases of mucocele was 0.35 per cent. To date, approximately 500 mucocèles, 39 with myxoglobulosis, have been recorded, to give an incidence of 7.8 per cent. However, there would be a tendency to report single cases of the latter, whereas the former would appear in the literature in larger series, thus, the true incidence of myxoglobulosis should be lower.

Case Report—This patient, a white male, age 54, entered the Jewish Hospital, March 24, 1945, on the service of Dr. Alfred Goldman. His chief complaints at that time were swelling in both lower extremities and cramping (substernal) pain. After examination, diagnoses of cardiac decompensation, moderate arteriosclerosis, chronic nephritis, and chronic passive congestion of the lungs were made. Laboratory examination was negative except for a 2 plus albumin and an NPN of 49. Decompensation therapy was instituted. On March 30, 1945, the patient developed nausea and an attack of abdominal pain, which seemed to be most severe on the right side of the abdomen. Examination revealed tenderness, rigidity and rebound tenderness over McBurney's point. There was no history of any previous attacks. Blood was noted in the stool on digital examination.

Laboratory Data—W B C 14,000, 5 stabs. Urinalysis 2 plus albumin. Blood

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N P N 49, diastase 61, total protein 66, albumen 45, globulin 21, cholesterol 239
Temperature 100° F, pulse 86, respirations 20 A diagnosis of acute appendicitis was made, bearing in mind the possibility of an acute mesenteric thrombosis and Meckel's diverticulum

FIG 1

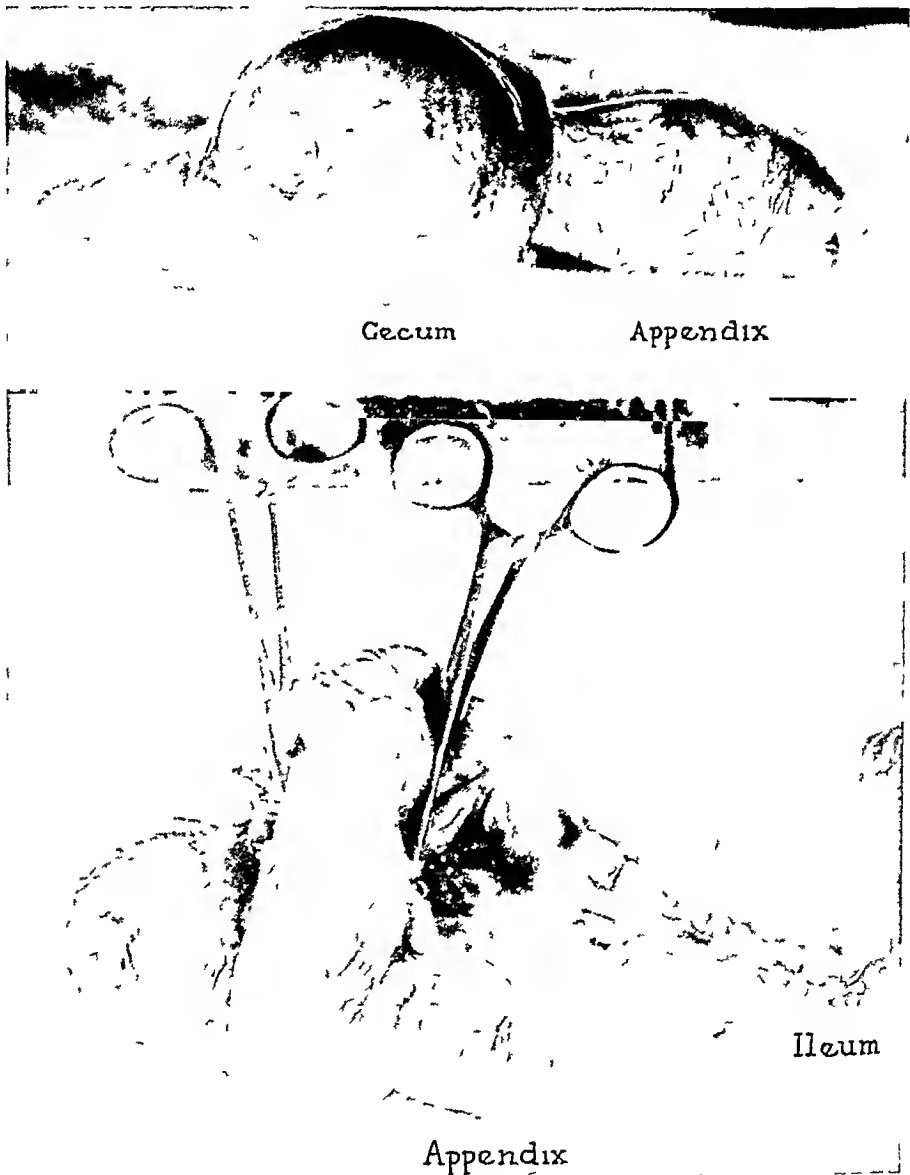


FIG 2

FIG 1—Specimen removed at operation, showing the dilated distal end of the appendix and the proximal end intussuscepted into the cecum (About two-thirds actual size)

FIG 2—The cecum end opened, showing the intussuscepted mucocoele (About two-thirds actual size)

Operation—On exploration, a very large, elongated, injected organ resembling a distended gallbladder was encountered. Upon further investigation the gallbladder was found to be in its normal position and not diseased. The mass proved to be a large, distended appendix, which was partly intussuscepted into the cecum (Fig 1). Because of

MUCOCELE OF APPENDIX

the patient's critical condition, the entire mass, including the cecum and ileum, was exteriorized and removed with a Rankin clamp. The abdomen was closed in the usual manner. The patient had a stormy postoperative course, but left the hospital well.

Pathological Report—Gross The specimen consists of a piece of ileum, the cecum, and a small portion of ascending colon. The appendix is transformed into an oblong sac, measuring 7 cm in length and 3.5 cm in diameter. The proximal one-third of the dilated appendix is invaginated into the lumen of the cecum and the portion of the cecal mucosa covering the intussuscepted sac is swollen and dark-red in color. The distal portion of the appendix is not involved in the intussusception and has a greyish, pale surface (Fig. 2).

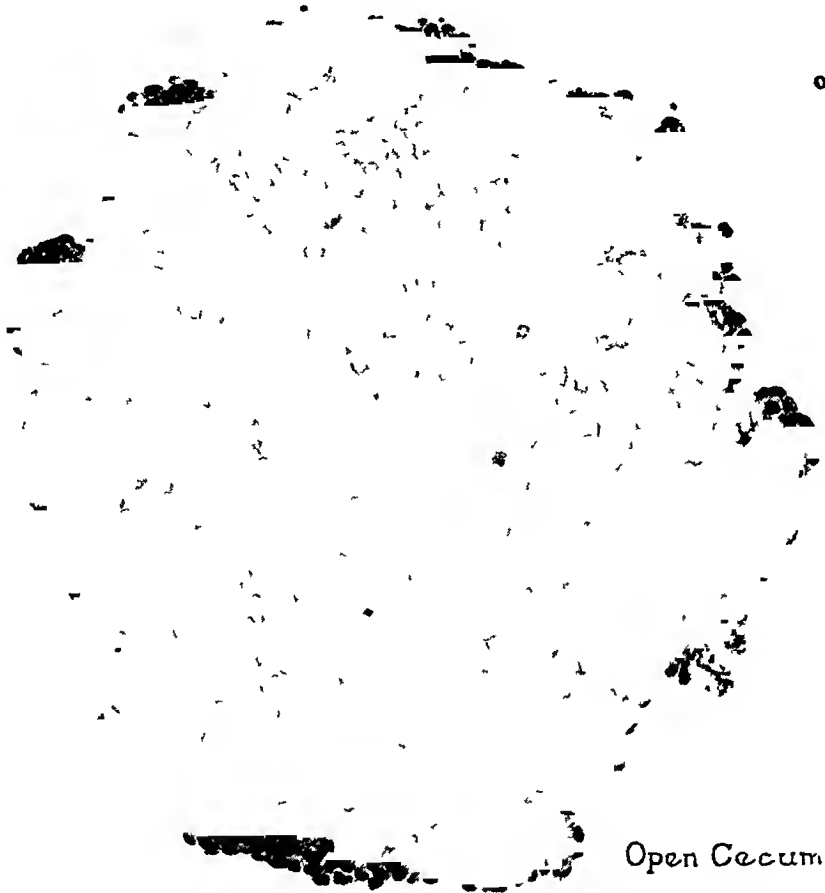


FIG. 3—Contents of the mucocoele composed of clusters of globoid bodies (actual size) spread out on a flat surface.

The distended lumen of the appendix contains about 80 cc of jelly-like material composed of hundreds of opaque white globules, measuring about 2 mm in diameter. Groups of them are glued together by a yellowish-white, mucoid material, creating the appearance of a cluster of fish eggs (Fig. 3). The wall of the dilated appendix measures 2 mm in thickness, it shows no definite stratification.

Microscopically, section through the wall of the cecum, covering the intussuscepted appendix, shows the epithelial surface for the most part destroyed and the remaining areas covered by a deposit of fibrin and leukocytes. There is marked hemorrhage into the wall and infiltration of all layers by polymorphonuclear and mononuclear leukocytes. The serosa is also poorly preserved. Sections through the wall of the dilated appendix fail to show any lining epithelium, although deposits of mucoid material, with scalloped edges, suggest the outlines of intestinal glands. In one area the mucoid material appears to be actually deposited within the submucosa. The wall is thickened and consists of layers of

longitudinal and circular muscle, and remnants of a submucosa, with a few inactive lymphoid follicles. The globules forming the contents of the appendix, when stained with haematoxylin and eosin, show an outer blue-staining, laminated hull and an eosinophilic center, which consists of finely granular material and contains numerous clear, linear slits (cholesterol slits). Examination of the fresh, unstained globules reveals typical cholesterol crystals. *Pathologic Diagnosis* Myxoglobulosis of the appendix with intussusception into the cecum.

COMMENT—The experimental work of Grodinsky and Rubnitz⁵ has contributed considerable information concerning the etiology of ordinary mucocoele. In 26 rabbits they ligated the proximal end of the appendix, carefully avoiding the blood supply and clearing, but not sterilizing, the lumen. They were able to produce mucocoeles by this method almost at will. Rubnitz and Hermann¹⁵ reported that of 24 mucocoeles produced by this artificial method, two showed myxoglobulosis, but they were unable to give a satisfactory explanation for this variation. They suggested that probably a combination of physical effects, such as a particularly forceful peristalsis from the hypertrophic muscles, together with changes in internal pressure of the mucocoele, are required to give this characteristic picture.

Pohl,¹³ and Cagnette³ believe that the same infection which results in the stenosis of the proximal end of the appendix also damages the glands. As a result, the orifices of some of the glands become stenosed and the secreted mucus is trapped. The mucous masses exert pressure on the epithelium, which becomes detached and accounts for the cellular elements often observed within the globules. Owing to reabsorption of water the secretions become inspissated, but they retain their globular shape. The pressure further increases, due to muscular action of the appendix, and the occluded glands finally burst, allowing the globules to escape and gain access to the lumen of the appendix. Here they coalesce with other globules and become rounded-off, in the same manner as rice bodies in a knee joint.

According to Poindecker¹⁴ a phlegmonous type of inflammation occludes the proximal portion of the appendix with formation of a mucocoele, which by pressure causes the appendiceal crypts to enlarge and to form small diverticula. The globules then develop in these diverticula by the same process as was described above.

Von Hansmann⁶ points out that the appendiceal glands are hardly large enough to accommodate the globules, which measure up to 2 mm. in diameter. He suggests that only the nucleus of the globules forms in the glands and the outer layer is added in the appendiceal lumen, which is borne-out by the different staining properties of these two layers. However, by this same line of reasoning it might be pointed out that the nucleus of the globules (the eosin-staining portion) measures 0.5 to 1 mm. in diameter and could not be accommodated by an ordinary-sized appendiceal gland.

The pathologic findings in our case agree for the most part with the previous reports of mucocoele with myxoglobulosis discussed in the literature. Destruction of the mucosa is a fairly constant finding, although Rubnitz and Hermann¹⁵ describe a marked hyperplasia of the mucosa, with papillomatous

proliferation in their artificially-produced cases in rabbits. Undoubtedly this is an early reaction, which probably changes as the pressure within the appendix increases

The chemical composition of the globules is still a matter of discussion. Most authors believe that the inner kernel, which stains red with eosin, is a pseudomucin, giving a negative test for mucin. It does not stain by the Weigert method for fibrin. The outer onion skin layer, on the other hand, stains with haemotoxylin, and not infrequently gives a positive test for mucin. Several authors have described cellular debris and epithelial cells as inclusions within the globules, but no mention is made of cholesterol crystals, as we found in the case reported above. They can easily be explained as products of cellular disintegration of the appendiceal mucosa. This would favor the theory that the globules begin their formation within the appendiceal crypts.

Based on all of the evidence available to date, we feel that the pathogenesis of myxoglobulosis is as follows. A very mild inflammation of the cecum or the proximal end of the appendix seals it off and produces a mucocele. The same process injures the glandular epithelium of the appendix and a number of epithelial cells are destroyed and sloughed-off into the lumen of the crypts. In addition, some of the mucinous material becomes inspissated in the appendiceal crypts, which enlarge as a result of increased pressure and the globules are formed. Intrinsic pressure from the globules within the crypts causes destruction of the epithelial lining and some of the cellular elements are included within the globules. When the globules grow too large for the crypts they are expelled into the lumen of the appendix, possibly with the help of peristalsis, and in the lumen they come in contact with the mucoid material present. Continued peristalsis rotates the globules and, thus, they collect layers of mucin and the outer shell assumes a laminated appearance. At the same time the remaining mucosal surface becomes further atrophied, due to the continued pressure within the appendix.

It is interesting that of the 38 cases of myxoglobulosis reviewed in the literature, only about six of these cases were operated upon for symptoms referable to the appendix. All of the others were discovered in the course of surgery for some other cause, or as findings in routine postmortem examinations.² Although several cases of intussusceptions related to simple mucocele appear in the literature, ours is the only case of intussusception caused by mucocele of the appendix, with myxoglobulosis.

SUMMARY

A case of mucocele of the appendix, with myxoglobulosis, associated with intussusception is reported.

Cholesterol crystals found within the globoid bodies, which have not been described previously, are considered indicative of destruction of epithelial cells in the crypts of the appendix. This debris together with inspissated mucus forms the nucleus of the globules, which later add to their size as they are expelled into the lumen of the appendix.

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CARCINOMA OF THE BREAST IN THE ABSENCE OF CLINICAL BREAST FINDINGS

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THE DETECTION of early malignant lesions of the breast is often impossible for the layman and even difficult for the physician because of the small size of the growth. More-and-more it has become apparent that the problem of breast cancer is a discouraging one and that the best hope for its successful treatment is early recognition and thorough eradication. The difficulty confronting the clinician in the early detection of this condition is evident from the report of the following cases.

Although these three cases were examined by several physicians, it was impossible to detect any clinical signs of pathologic abnormality in the breasts of any of the patients. If similar instances have been previously observed and recorded, a cursory review of the voluminous literature on carcinoma of the breast failed to reveal it.

CASE REPORTS

Case 1—A female, age 62, was referred to the Clinic on April 21, 1943. The patient stated that two months prior to admission she had noticed a tumor mass in the right axilla. At first the growth was small and was described as bean-size, this had gradually enlarged until at the time of admission it appeared about the size of a hen's egg, and was deeply imbedded in the axilla and apparently attached to the axillary vein. The growth was firm and not freely movable. It appeared rather hard and nodular, and seemed definitely malignant, although the possibility of tuberculosis and Hodgkin's disease had to be excluded. A careful breast examination revealed no abnormality in either breast. There were no demonstrable lymph node enlargements elsewhere. The general physical examination was otherwise negative. A differential and complete blood count was normal. Roentgenologic examination of the chest was negative.

Operation—On April 26, 1943, under gas-ether anesthesia the tumor mass was excised. It was adherent to the axillary vein and was hard and nodular and 6 by 4 cm in size. It appeared grossly malignant, and this impression was confirmed by a frozen-section examination. The possibility of a malignant degeneration of a supernumerary breast was considered, and the prognosis was believed unfavorable.

Permanent tissue examination was reported by the pathologist, Dr. Henry Bunting, as follows: "Section shows carcinomatous metastases in lymph nodes, which one could casually assume were from the breast. If that possibility has been ruled out, there is some histologic evidence that the tumor may be from the large sweat glands of the axilla, if the mass appeared adherent to the skin, I should think that origin almost certain."

The mass did appear adherent to the skin, and, in the absence of any signs of pathologic changes in either breast, the condition was considered as a primary sweat gland tumor of the axilla. However, in the light of my experience since that time I would have made a different decision in regards to this case as may be judged from the following:

For the next six months the patient was given several treatments with radium packs to the axilla. From that time she returned for follow-up examinations every three months until August 27, 1946. She stated that two weeks prior to that date she had noticed a small lump in the right axilla. Examination revealed a recurrent, hard, nodular, fixed mass deep in the right axilla. However, at approximately 3 o'clock in the right breast, about 5 cm from the nipple, there was a firm, hard mass about 3 x 3 cm. There was no retraction of the nipple, but the skin was attached. Thus, three years and four months after the removal of the axillary node mass the probable primary tumor became apparent in the breast. This tumor, of course, had been present in microscopic form for several years, but repeated clinical examinations of the breast by several physicians every few months failed to reveal any gross evidence of it.

From experience gained in the following two cases, in retrospect, I would have performed a radical breast amputation as soon as a pathologic examination had indicated that the axillary nodes were malignant. On August 27, 1946, a radical breast amputation was performed, however, it was impossible to satisfactorily clean out the axilla because of dense scar attachments to the axillary vein, the result of the previous operation and of the radium therapy. At the present time there is no other evidence of further metastasis, and the patient's health is good.

The pathologic examination showed "carcinoma of the breast, with considerable differentiation of cells."

Case 2—On October 13, 1944, a 37-year-old single woman came to the Clinic because she had accidentally found a lump in her left axilla the day previous. Examination by Dr. Harold Marsh revealed a small movable mass that was hard and about the size of a marble. No other nodes were palpable, and careful examination of the breast revealed no evidence of any pathologic changes. A dissection of the axillary nodes was performed by Dr. Luther Holmgren, and the pathologic examination by Dr. Henry Bunting showed a metastatic cancer, adenocarcinoma in type, but becoming simplex. On the basis of this report it was decided to perform a radical amputation of the left breast, which was done on November 30, 1944. Gross examination revealed several minute areas suggestive of carcinoma in the lower portion of the breast as well as several small nodes. The patient received postoperative radiation therapy and, when last examined on September 3, 1946, was in good health.

Case 3—On October 10, 1946, a married woman, age 50, came to the Clinic because of a lump in the left axilla first noticed some five months prior to admission. When first noticed, the lump was described as being the size of a marble, and no enlargement had been observed.

Examination by Dr. Harold Marsh revealed two discrete nodes in the left axilla. They were hard but movable. Physical examination including a careful study of both breasts was otherwise negative. A roentgenologic examination of the lungs was negative. On October 24, 1946, excision of the axillary nodes was performed, and the following pathologic report was given by Dr. D. M. Angevine: "Medullary carcinoma. Origin is not clear from data given. Unusual location for metastasis from carcinoma of lung, but this is a possibility."

In the light of the two cases reported above another very careful examination of the patient's breasts was made without revealing any abnormalities. Not satisfied, I called into consultation several of my associates, all of whom corroborated my findings. The experience with the other two cases was reported to the patient and her relatives, and despite the negative examination a radical removal of the left breast was advised. Consent for the same was given, and on October 29, 1946, this operation was performed. When the breast was removed and turned over, several suspicious areas the size of a match head could be palpated but scarcely distinguished from the surrounding tissue. There was one node that appeared involved. The pathologic report by Doctor Angevine was as follows: "Breast specimen consists of a breast with irregular, firm, gray bands radiating out from

the nipple and extending into fat. There is also a lymph node measuring 1.2 x 1 cm that is very firm. On sections, there is a carcinoma of duct type, with extensive involvement of the lymph node. *Pathologic Diagnosis*: Carcinoma of breast, with metastasis to a lymph node."

The patient made an uneventful recovery and is now receiving radiation therapy.

These three cases illustrate the need of a careful examination of the axilla of all patients despite negative breast findings. If axillary nodes are found, they should be removed for pathologic examination, and, if found to be malignant, the advisability of a radical breast amputation should be given most serious consideration.

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HAMARTOMA OF THE LIVER

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HAMARTOMA OF THE LIVER, a distinctly rare entity, if judged by the paucity of cases reported, deserves mention when encountered because it represents a resectable and curable tumor in an organ commonly involved by hopeless neoplasms

Hamartoma (*ἁμαρτία*, error or defect, and *-ωμα*, tumor) is a term coined by Albrecht¹ in designation of certain tumors which cannot be classified with the true neoplasms, which have a relative quantitative disproportion of tissue elements normally comprising the organ, but which have not attained the complete pattern of the organ. These tumors are congenital and of a teratoid nature, with retention of some embryonal characteristics, they are more or less encapsulated, do not contain mitotic figures and do not metastasize. In the indexed titles of the literature of the past ten years the term, hamartoma, has been used in connection with tumors of the skin, tympanum, brain, choroid plexus, thyroid, lung, bronchi, spleen, heart, mediastinum, and liver. Hamartoma of the liver is generally found in the infant. Ladd and Gross⁵ described an hamartoma of the liver, weighing 400 Gm, successfully removed from an infant of eight months. Benson and Penberthy,³ in 1942, excised a similar tumor, weighing 60 Gm, from the liver of an infant seven months of age with recovery.

Case Report—No 18591. R O, white, female, age 16 5 months, was admitted on the Pediatrics Service of Memorial Hospital by Dr J Keller Mack, September 15, 1946, because of enlargement of the abdomen. She had been born by cesarean section because of postpoliomyelitic deformities of the mother, and had always appeared in normal health, though her abdomen was always noted to be large. No abnormality was detected by her family doctor until he found an abdominal mass about two weeks before admission.

Physical Examination A well-developed child, weighing 24 pounds, and standing with moderate irreducible protrusion of the abdomen (Fig 1). A rounded, partially lobulated, firm mass extended from the right costal margin into the iliac fossa, filled the right flank and extended across to the left nipple line, occupying about two-thirds of the abdomen. Examining fingers could be inserted beneath the costal margin, but the upper border of the mass was indefinite, the lower border was freely palpable, and the tumor could be moved slightly, with no apparent pain, it was less well-palpated through the flank.

Laboratory Data Hemoglobin 11.5 Gm (74 per cent), R B C 3.99 million, W B C 8,600, lymph 58, seg 32, stab 21, eosin 4, mono 4. Urinalysis was normal.

Roentgenograms showed a large homogeneous mass in right side of abdomen. After barium enema the mass was seen to displace the proximal colon downward and posteriorly (Fig 2). Intravenous pyelogram showed no dye in right kidney, but retrograde examination showed normal pelvis and calyces on right.

Course After preliminary blood transfusion, and with a diagnosis of probable mesenteric cyst, operation was performed, September 21, 1946, under vinyl and ethyl ether inhalation anesthesia. Through a long right rectus incision the tumor was immediately encountered and delivered (Fig 3). It measured 8 x 7 x 4 inches *in situ*, and in shape, size, consistency and color bore a striking resemblance to a beef heart, the base was broadly incorporated into the right lobe of the liver, and the medial border lay immediately adjacent to the gallbladder, the apex felt cystic, large veins coursed beneath the serosa of the tumor into the liver. Complete excision required resection of nearly half of the right lobe of the liver, which was accomplished without great difficulty by preliminary placement of mattress sutures of No 1 chromic catgut, the lateral half of the resection was facilitated by temporarily compressing the liver with a rubber-shod intestinal clamp. The capsule of the tumor did not completely enclose the base where the tumor tissue blended with normal liver, but it was considered to have the gross characteristics of a benign lesion. Mild shock ensued during traction on the liver despite blood replacement, it was estimated that less than 200 cc of blood was lost, but a similar amount was probably contained in the tumor. The raw stump was allowed to retract above the mesocolon without reperitonealization. The wound was closed with No 0 chromic catgut for peritoneum and No 30 cotton for fascia. A small Penrose drain was left inlying to the stump.

The patient developed a rectal temperature of 104.2° F eight hours after operation, and this gradually decreased to normal by the 8th day, when the drain and sutures were removed. Adequate urinary output was assured by intravenous solutions. Abdominal distention was present for three days. She was discharged on the 11th postoperative day. Examination five months after operation disclosed that her physical development had proceeded normally and there was no evidence of recurrence of the tumor.

Pathologic Examination (Dr A Vass) —

Gross A heart-shaped mass 17 x 17 x 9.5 cm, weighing 1,575 Gm (Fig 4A). On section (Fig 4B), the entire mass consists of roughly lobulated, firm but elastic yellowish-pink tissue, the lobules measure from 2 to 5 mm in diameter and are separated by septa less than 1 mm in width. In the distal portion is a roughly spherical 8-cm cyst containing clear yellowish fluid and lined by a smooth pinkish-gray transparent membrane with incomplete septa. Several similar but smaller cysts were found on further section. At the base a 3 to 4 mm layer of reddish-brown liver tissue is noted to be well-demarcated from the adjoining tumor tissue.

Microscopic The liver tissue present at the proximal end of the specimen appears to be quite normal. Very slight infiltration by round cells is present in periportal connective tissue. However, in the zone of the liver which adjoins the tumor mass (Fig 4C) the periportal connective tissue contains rather irregularly-shaped glandular structures which

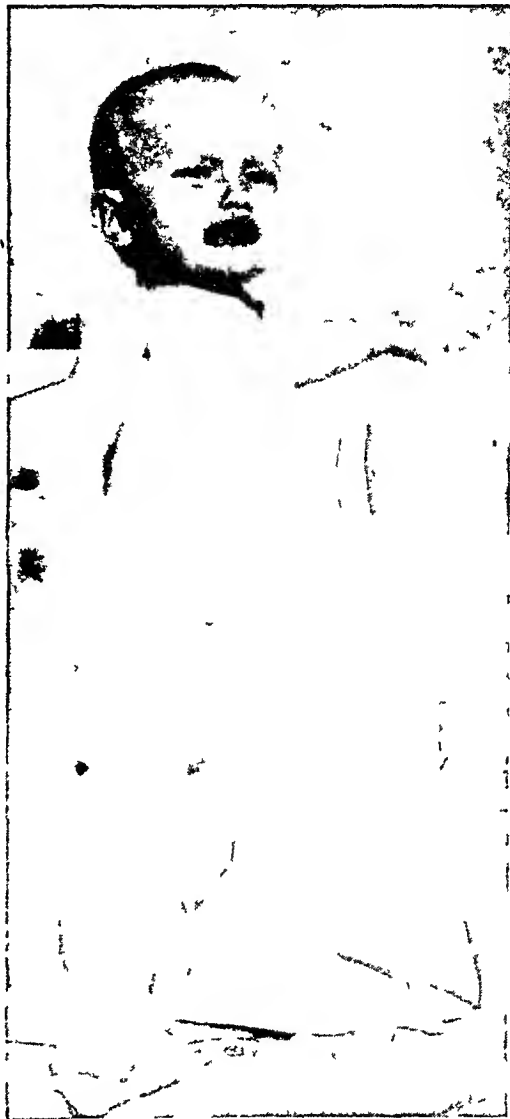


FIG 1—Preoperative photograph demonstrating enlarged abdomen



FIG 2—Roentgenograms, A anteroposterior, and B lateral, demonstrating inferior and posterior displacement of right colon

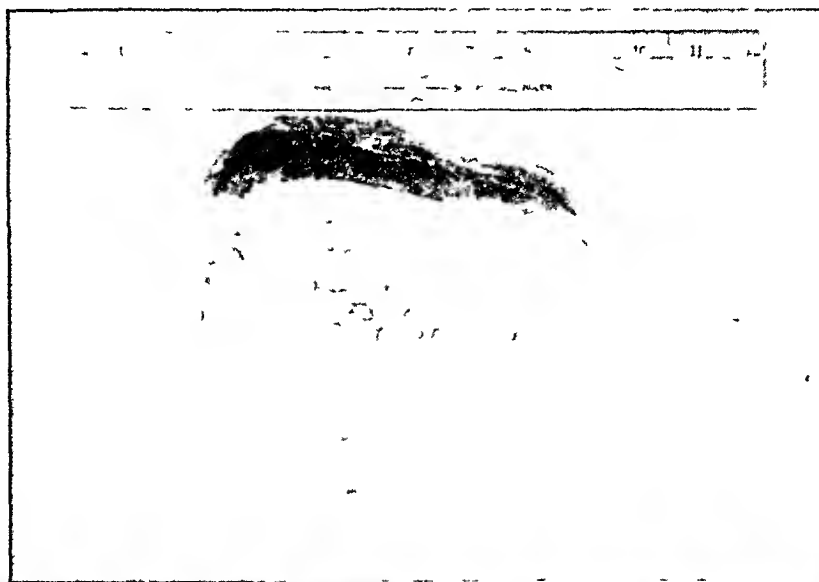


FIG 3—Appearance of tumor at operation Hemostat indicates attachment to liver

HAMARTOMA OF LIVER

are more or less haphazardly arranged. They are lined by a single to double layer of cuboidal epithelial cells most of which possess vesicular and only occasionally hyperchromatic nuclei. Often these structures are surrounded by groups of lymphocytes and a few eosinophilic polymorphonuclear leukocytes. The structures are not always confined

A



B

FIG 4—Gross specimen A after excision, and B after section, demonstrating cyst at apex

to the periportal connective tissue but are also found between the adjoining liver cords. The structures are not infrequently surrounded by apparently newly-formed moderately cellular connective tissue. These structures resemble bile ducts in a general way. Sections from the periphery of the tumor (Fig 4D) reveal it to consist of rather abundant, somewhat edematous, hyalin connective tissue forming the stroma into which are embedded

numerous glandular structures similar to those described above except that they are more irregular in shape and are somewhat distended. They contain traces of pinkish-staining homogeneous material. Occasionally there are papillary projections of connective tissue into the lumina. These projections are covered with cuboidal cells similar to those lining the lumina elsewhere. There are also a large number of rather distended capillary blood spaces lined with a single layer of flat endothelial cells. Occasionally the arrangement of connective tissue about these spaces is similar to that seen in veins. Small islands of polygonal, moderately large cells, possessing somewhat hyperchromatic moderately large nuclei and somewhat eosinophilic cytoplasm, are scattered throughout the section. These

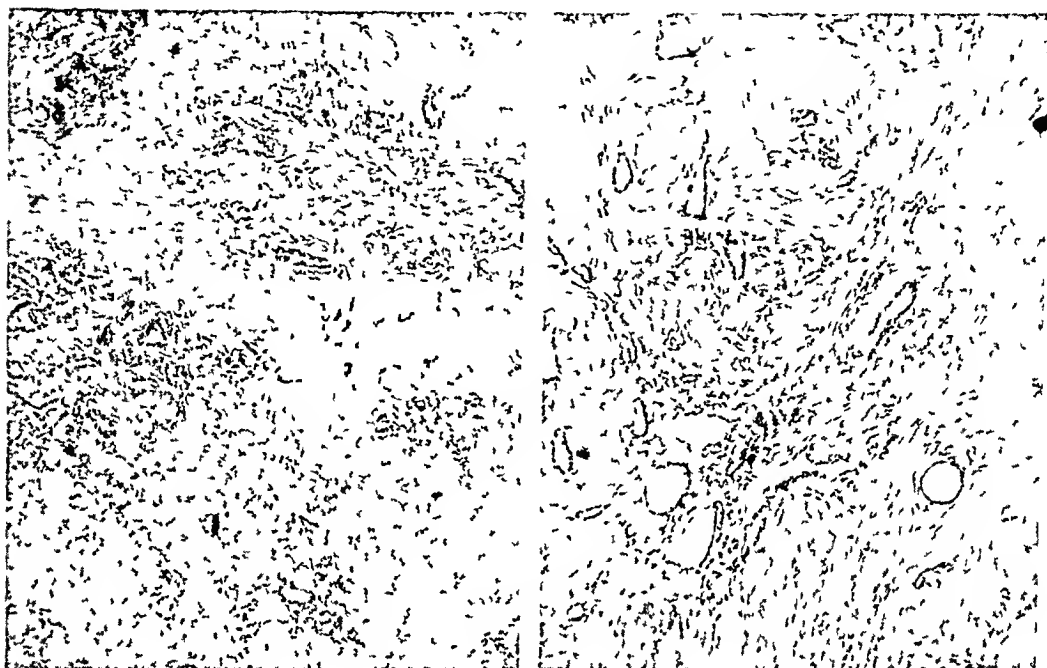


FIG 4C

FIG 4D

FIG 4 (Cont'd)—Photomicrographs demonstrating C liver-like tissue near base of tumor, and D fibrocystic appearance near apex

resemble liver cells and sometimes are continuous with the above mentioned glands
Pathologic Diagnosis Hepatoid hamartoma. A tumor of complex embryonal origin, probably arising from the multivalent liver cell, and possibly malignant

DISCUSSION—Sections from this tumor were reviewed by another pathologist* who agreed that it was classifiable as hamartoma under the present usage of the term, considered it benign but preferred a more descriptive term such as "benign mixed cystic teratoid tumor"

In a classification of true primary tumors of the liver, Warvi^{10, 11} considered hamartomas to be indistinguishable from adenoma of the liver, a more common and usually benign tumor. His opinion was based on review of material demonstrating a preponderance of liver cords without bile ducts or

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portal triads, a type of tissue not exactly comparable to our case nor to that of Benson and Penberthy who permitted the author to study their sections which resemble the proximal portion of the tumor here reported. Further case studies should be reported to permit a more precise classification of these tumors and to define their relationship to other benign tumors composed of hepatoid elements. It is possible that the variable criteria for the diagnosis of adenoma of the liver may have resulted in the classification of hamartomas with adenomas in other series.⁸

It would appear inaccurate to liken the tumor in our case to adenoma, cystadenoma or cholangiohepatoma as the proportions of liver cells, bile ducts and fibrous tissue varied within the tumor itself, there being, at the base (Fig 4C), a less mature but more liver-like tissue than at the apex (Fig 4D) where liver cells were scarce and fibrocystic tissue predominated. A comparable tumor removed from the liver of a 13-months-old infant and weighing 4.5 pounds was described by Lee⁶ as "large solitary bile-cell fibro-adenoma of the liver." It is this abnormally great development of supporting connective tissue that is described by Albrecht² in his discussion of hamartoma and hamartoblastoma. In a former article¹ he regarded the two main possibilities of the manner of origin of fibrocanalicular hamartomas as (a) abnormally abundant formation of connective tissue as a result of increased anlage or greater localized power of proliferation of mesenchyme cells, and (b) abnormal relative activity between the canaliculi-forming and the supporting tissue cells.

The tumor in our case weighed 1575 Gm., nearly five times the weight of the average liver of this age, which is said to be 331 Gm.,⁴ and composed one-seventh of the patient's total weight.

These tumors apparently occur most often in the right lobe of the liver. Characteristic displacement of the colon downward and posteriorly, but not forward as in the more common Wilm's tumor, a normal pyelogram and a tumor of the upper right abdomen more easily palpable anteriorly than in the flank should suggest the possibility of a primary liver tumor in an infant. Hamartoma cannot be distinguished from adenoma without exploration.

The technic of resection of the liver is fairly well-standardized^{7, 9, 11}. Improved anesthesia and restorative therapy now permit resection of liver tumors with increased safety. Fibrin foam or gelatin sponge with thrombin should be useful hemostatic adjuncts. The febrile postoperative course of our patient was not adequately explained but may have been the result of liver trauma.

SUMMARY

Hamartoma of the liver is a structurally variable but benign and resectable tumor of the liver which occurs predominantly in infants. Despite the frequency of malignant liver tumors, surgical exploration is considered justifiable because of the occasional occurrence of hamartoma or other benign tumor, in which case a good prognosis may be given if the tumor is totally removed.

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A CASE OF GLOMUS TUMOR WITH PRIMARY INVOLVEMENT OF BONE

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SINCE PIERRE MASSON, in 1924, published his paper entitled "Le glomus neuro-myo-artériel des régions tactiles et ses tumeurs," the neuromyo-arterial glomus and its tumors have been the subject of numerous and often excellent publications

Although definitely uncommon, the glomus tumor has now become a well-recognized clinical and pathologic entity. A preoperative diagnosis based on the typical history and symptoms is often possible, and the microscopic characteristics of the neoplasm are now well known to the pathologist. It would, therefore, seem superfluous to report another case were it not for one reason, *i e*, its location which, as far as we are aware, has been reported only once before in the literature

Case Report—Clinical History The patient is a 28-year-old white woman who came to the hospital with the chief complaint of pain in the right thumb of about four years duration. The past history is noncontributory except that about ten years ago her right hand was caught in the door of a train injuring the thumb. She, however, does not remember that at that time any ecchymosis or incapacitating wound resulted.

The symptoms developed gradually and consisted of a sharp and stabbing pain recurring at irregular intervals and not relieved by aspirin or warm water soaks. Apparently with the pain there always were associated small deep vesicles of the skin of the distal phalanx of the same thumb.

Physical Examination Blood pressure 108/76. The thumb nail appeared enlarged and curved in all directions. The finger was slightly enlarged and the skin somewhat thickened and discolored. These areas of red discoloration were painless to the touch. On the volar surface there was an area of paler skin in which lay many deep vesicles filled with clear fluid. There was cyanosis of the nail bed and the whole finger was warmer than the others. The skin of the finger was sensitive to the touch. The superficial radial vein of the thumb appeared enlarged.

Roentgenograms (Fig 1) showed honey-combed areas of decalcification of the distal phalanx suggesting cysts or an enchondroma.

On the basis of these findings, the clinical diagnosis varied as follows: (A) Passive congestion possibly caused by cervical rib (disproved roentgenologically) (B) Chondroma (C) Bone cyst (D) Glomus tumor.

On December 15, 1944, the patient was operated upon by one of us (D B) under avertin-gas-oxygen anesthesia. No soft-tissue masses were found. The terminal phalanx of the thumb was found to be almost completely replaced by areas of softening containing a jelly-like material. Only a paper thin cortex was left. The lesion was curetted and the defect was filled with a bone graft. The patient, seen recently, more than one year after the operation, appears to be completely cured of the symptoms caused by the intraphalangeal tumor. Roentgenograms demonstrate the bone graft to have maintained the full length of the phalanx if not quite the entire diameter.

Pathologic Examination—Gross (S P 91809) This consisted of a few small, irregularly-shaped fragments of jelly-like pale tissue, the largest of which measured about 6 mm in average dimensions. A few small spicules of bone were also present.

Microscopic Examination (Figs 2 and 3) Sections show a neoplasm, the main characteristic of which consists of the presence of "epithelioid" cells arranged in perivascular cuffs around numerous endothelium-lined spaces. The tumor cells are polygonal and, in general, closely apposed and contain round nuclei with one or more small nucleoli. Around the nuclei sometimes there is a clear halo in the cytoplasm. Besides the above described perivascular arrangement, the neoplastic elements form also solid masses and cords. These are separated by a loose, poorly cellular, myxomatous tissue in which are often found elongated, spindle-shaped elements resembling smooth muscle cells. However, myofibrils cannot be made out with certainty in these cells. Well preserved bone lamellae are seen here and there in the neoplastic tissue (Fig 2). A



FIG 1—The bone of the terminal phalanx shows multiple cyst-like areas of decalcification

Laidlaw stain for reticulin shows the presence of delicate argentaffine fibers between the tumor cells. Furthermore, it shows that in the perivascular cuffs the tumor cells are all arranged outside the reticulin membrane of the vessels, thus, ruling out a possible endothelial origin of the neoplasm.

The histologic features are typical of a glomus tumor. The presence of spindle-shaped glomus cells that appear to represent a transition between the typical epithelioid elements and smooth muscle cells finds its counterpart in the normal neuromyo-arterial glomus in which there is a gradual transition from the smooth muscle cells of the afferent arteriole to the glomus cells surrounding the "Suquet-Hoyer canal," and then again to the smooth muscle of the efferent vein.

As already mentioned, this case was considered worthy of publication because of its unusual location within the bone of the terminal phalanx.

In the collection of the Laboratory of Surgical Pathology of the College

of Physicians and Surgeons, there are now 44 recorded cases of glomus tumors distributed as follows *

Fingers 22, of which 11 are subungual

Toes 2, both subungual

Forearm and arm 8

Lower extremity (thigh and leg)

10, of which 1 is in the capsule of the knee joint, and another one in the malleolar region showing features of malignancy

Gluteal region 1

Lower eyelid 1

Only one other report of a glomus tumor completely encased in the bone of a phalanx could be found in the medical literature. This was published in Cuba by Iglesias de La Torre, Gomez-Camajo, and Palacios. The patient was a 32-year-old woman who had been complaining of severe pain of four years duration affecting the whole upper left extremity but subject to paroxysmal exacerbations following the slightest trauma to the tip of the left ring finger. The inspection of this finger did not reveal anything noteworthy, but there was an exquisite tenderness of the last phalanx. The fingernail and the nail bed were apparently normal. Roentgenograms showed a small cystic cavity 0.5 cm in diameter. The patient was completely cured following disarticulation of the last phalanx, and the intraphalangeal cavity was found to contain a typical glomus tumor.

This is, therefore, probably the second case report of a glomus tumor completely encased in bone. Other well-documented cases can be found in the literature of glomus tumors arising away from the cutaneous-subcutaneous junction, where normal glomera are exclusively found, according to the studies of Masson.

The occurrence of such cases can be explained in two possible ways (A)

* It might be interesting to note that this group of glomus tumors shows an absolute predominance of females for the tumors arising in fingers and toes (21 out of 25), and of males for those tumors distributed in the other regions of the body (18 out of 24). Another noteworthy feature is that only one of the cases of this series behaved in a malignant fashion.



FIG 2—Low power photomicrograph showing the close relationship between a lamella of bone and the neoplastic tissue

By speculating on the existence of normal neuromyo-arterial glomera anywhere in the body, but so sparsely distributed as to make it practically impossible to find them on routine histologic examination. This is pure speculation, as it is not supported by any positive data. (B) By considering the glomus tumor as an hemangiopericytoma of a highly differentiated and specialized variety.

The problem of the distribution of the glomic tumors, and of the significance of their occurrence in regions in which no normal glomera are found



FIG 3—High power photomicrograph showing the typical structure of the glomus tumor

has been the object of very interesting studies published in 1942 by Murray and Stout. These authors, studying explants of a glomus tumor by the method of tissue culture, concluded that there are no fundamental differences between the "epithelioid" cell of the glomus and "pericyte" of Zimmermann. This cell, which Zimmermann considered a modified smooth muscle cell, was found by him around blood capillaries. Possibly it is identical with the contractile adventitial cells described by Rouget, and others.

Murray and Stout felt that the identification of the glomus cell as the pericyte of Zimmermann offered a satisfactory explanation for the occurrence of glomic tumors away from the regions where normal glomera are found.

One might argue that the glomus tumor consists of a complex growth of an organoid character due to the presence, in addition and in close association with the epithelioid "pericytes," of large numbers of nerve fibers and fre-

quently of smooth muscle cells. On the other hand, the hemangiopericytoma as described by Stout and Murray is relatively a simpler growth which is the result of a neoplastic proliferation of poorly differentiated perivascular elements. However, it is very probable that both the glomus cell and the pericyte represent modified smooth muscle elements from the walls of the blood vessels. Most likely they both descend from a common undifferentiated stem cell, and it is, therefore, conceivable that a neoplasm arising from such stem cell might differentiate into a glomus tumor even if no normal glomera are normally found in that particular region.

SUMMARY

A case of glomus tumor completely encased in the bone of the terminal phalanx of a finger is presented. Only one other report of a similarly located glomus tumor could be found.

The pathogenesis of glomus tumors arising where no normal glomera have ever been found is briefly discussed.

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SPECIAL NOTICE

U S PUBLIC HEALTH SERVICE RESEARCH GRANTS PROGRAM

THE U S PUBLIC HEALTH SERVICE RESEARCH GRANTS PROGRAM, which has been in operation since 1946, is financed by public funds in the support of research—conducted without government control—by independent scientists. The purpose of these grants is to stimulate research in medical and allied fields by making funds available and by actively encouraging scientific investigation of specific problems on which scientists agree that urgently needed information is lacking. Since 1946, a total of \$11,061,000 has been provided for the program, exclusive of appropriations for research grants in the fields of cancer and mental health. A total of 16 grants, which represents an expenditure of \$159,910, has been approved.

Late in 1945 the Research Grants Division was established to administer the grant program of the Public Health Service with Dr C J Van Slyke as Chief. In July 1947, in order to coordinate programs of research grants and research fellowships, the U S Public Health Service Fellowship Program was delegated to the Research Grants Division, which is now known as the Division of Research Grants and Fellowships.

Final recommendations to the Surgeon General of the Public Health Service are made by the National Advisory Health Council regarding all research grants except those relating specifically to the fields of cancer and mental health, for which the National Advisory Cancer Council and the National Advisory Mental Health Council are responsible, respectively.

At the request of the National Advisory Health Council the fields of medical and allied research were classified into 20 major categories, and Special Study Sections made up of consultant experts in these 20 fields have been established. Late in 1946 the Surgery Study Section was organized with Dr Frederick A Collier, Professor of Surgery, University of Michigan School of Medicine, as Chairman.

The 16 grants which have been activated in the field of surgery cover the following general subjects: Mitral stenosis, hyperactivity of sympathetic efferent nerves, revascularization of the heart, experimental pulmonary stenosis, development of a pump-oxygenator for use in surgery, parasympathetic regulation of gastrointestinal activity, therapy of debilitated surgical patients, systematic metabolic changes following trauma, peritonitis of intestinal origin, biliary pancreatic reflux and diseases of pancreas and biliary tract, restoration of circulation after arterial severance, complications after vagotomy, amino acids and wound healing, etiology of acid-peptic ulcer, and etiology of ulcerative colitis.

There is, of course, great urgency for additional studies in the field of surgery. Specifically, information is needed concerning shock, heart and lung complications, infection, anesthesia, and wound healing. There is reason to believe that the ratio of complications and death may be 10 times higher with some anesthetic agents than with others.

Shortening of the period of disability following operation is a major economic and public health problem.

The development of new surgical procedures is needed for the solution of old problems, such as cancer, heart disease, hypertension, kidney and liver disease, peptic ulcer and tuberculosis.

Research must develop safe methods for reducing the hazard of surgery in the aged.

Applications for grants may be submitted at any time and should be addressed to Chief, Division of Research Grants and Fellowships, National Institute of Health, Bethesda 14, Maryland.

THE SYNDROME OF THROMBOTIC OBLITERATION
OF THE AORTIC BIFURCATION

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ONE OF US HAS DESCRIBED, in 1940,⁶ a very peculiar and typical syndrome related to thrombotic obliteration of the end of the abdominal aorta. This new syndrome has no relation to the dramatic and well-known "saddle embolism" seen in cardiac patients and long since described in textbooks. The thrombotic disease appears to be a disease with a long course, presenting, for a long period, symptoms which have no meaning for the physician, unpleasant as they may be for the patient. It may remain compatible for years with a seemingly almost normal life. From the scarcity of reports in the world literature, it might be assumed to be rare. On the contrary, our feeling is, that its occurrence is not infrequent, and that adequate knowledge of its components will help to discover a fair number of cases which otherwise would remain misunderstood.

CLINICAL FEATURES

These appeared very clearly in our original cases (Leriche, 1940)⁶, and they appear in all observations published since (Martorell, 1942, André Morel, 1943, Delannoy, Ameline, 1945, Moulonguet, 1945, Peycelon & Gallavardin, 1945, Friehe & André Morel, 1946, Servelle, 1946, Christophe, 1947 as well as in unpublished cases of our own).

As a rule, patients are young adults (the youngest of ours was 29), mostly males—but Delannoy reports a woman, aged 41.³ In general, their past history is irrelevant. They come to the physician for one or the other of the following symptoms:

In the male inability to keep a stable erection, the blood flow being insufficient to fill the spongy processes. (This sign is often met with in patients with high located arteritis of the ilio-femoral trunk, and is caused by vasospasm of the major pelvic arteries. It is not permanent, and sometimes disappears following bilateral lumbar sympathetic ganglionectomy, with favorable results.) If the disease is left to itself, sexual impotency will soon be permanent.

* From the College de France, Paris

Extreme habit to fatigue of both lower limbs It is not the well-known "intermittent claudication," but an extreme weariness, which comes quickly on walking, sometimes even in ordinary standing position

Usually a *global atrophy of both lower limbs* which it is difficult to appreciate as a normal limb lacks as a term of comparison One must be on one's guard, not to overlook bilateral atrophy

No trophic changes, either of the skin, or of the nails Toes look normal It is difficult to believe that the circulation is severely impaired An important fact must however be noted if there is an error in the diagnosis, and if an incision is made in the limb for peri-arterial sympathectomy (inadvisable in such cases), or any other operation, *the wound heals either very sluggishly or not at all*

Pallor of the legs and feet, even when standing At rest, the limb looks as if a Martin rubber bandage had just been released When the legs are raised to the vertical, the pallor becomes striking, being like ivory or marble

The *clinical investigation* reveals, moreover

- that no pulse can be found, either in the leg, or in the groin The iliac pulse is not felt That of the aorta will be perceived very high-up, above the umbilicus
- that oscillometric findings are no oscillations in the leg or thigh, a slight thrill close to Poupart's ligament
- that blood pressure is a trifle high in the upper limb, without any renal disturbance

DIAGNOSIS

One should never diagnose a "neuritis" or a "polyneuritis" of the lower limbs, unless one has carefully examined the femoral pulses and the oscillometric curve Bearing this in mind, diagnosis is easy In fact, when a patient complains of impotency, or of severe fatigability of the lower limbs, or of pain in the thighs on exertion, if the physician finds alterations in the peripheral pulses, the provisional diagnosis of thrombotic obliteration of the aortic bifurcation may be made When no pulse has been found on either side, in the dorsalis pedis, tibial, femoral and iliac arteries, when oscillometry at ankle, calf and thigh is confirmative, the diagnosis is probably accurate Indeed, since our first description, the above-mentioned authors have discovered and diagnosed their cases with these simple means of investigation The only difficulty is the recognition of an obliteration localized in both common iliac arteries, but, as thrombosis of the whole bifurcation often begins thus, inaccuracy of the diagnosis is of no consequence

In almost all cases, clinical data, a shrewd study of the patient's history, and oscillometry, will lead to the discovery of the origin of all troubles AORTOGRAPHY, as originally developed by Reynaldo Dos Santos,⁴ will give a new and precise support to the diagnosis It should be performed under short barbiturate anesthesia If the patient is heavy, or presents signs of diminished

cardiac output, or has cyanotic legs with violaceous bluis, aortography is to be avoided, because in such instances its performance may lead to the extension of thrombosis, with fatal result. In properly selected cases, aortography gives a neat picture of the lesions, of their extent, of the thin net of anastomoses and by-ways which, through all subcutaneous, muscular, diaphragmatic, epigastric, ilio-lumbar, etc., arteries, allow a very scanty, though vital blood supply, to reach the ischemic limbs. Aortographies in man often show the same pictures as in Luigi Porta's hundred-year-old book (ligatures on animals, Milan, 1845).

PROGNOSIS

Aortic thrombosis, although apparently very well-borne for years (5 and even 10) always ends in gangrene. The onset of gangrene is not sudden, and not always bilateral. It is usually preceded by an increase in muscular atrophy of legs and thighs, and by a growing impairment of walking. Muscles vanish in a few weeks or months. There then appear edema, a general violaceous hue of the legs, with ecchymotic suffusions, and soon, sores on all pressure points, not only on the sacrum and back, but also on iliac crests, the rotula, the malleoli, the heel. Finally, gangrene supervenes, *ie*, dry gangrene, in the extremities, and in plates on leg, trochanter, and sides of the foot. Such an outlook of scattered and widespread dry gangrene, is typical enough. Lesions progress slowly accompanied by deep suffering which nothing can soothe, and death comes at length through heart, lung or kidney. The prolonged survival can be explained by the above-described anastomoses. The onset of the terminal period is due to upward and downward extension of the thrombosis, and sometimes to associated peripheral venous thromboses.

PATHOLOGY

The pathologic characteristics have been revealed in a small number of cases by postmortems, and mostly by the findings at operation. In some cases, the thrombosis seems to begin in one of the common iliac arteries. It then extends upwards, reaching the aorta and hampering the blood flow to the opposite side, but without, for a long time, stopping it totally. The final result is obliteration of both iliacs and aortic bifurcation.

In less frequent instances, the disease is at first on the aorta, and the iliac thrombosis is secondary. Whatever the beginning, thrombosis finally lies on at least 2 or 3 cm. of the aorta, and extends to both common iliac arteries, the obliteration of which is complete. Sometimes, the common iliacs have become hard, string-like sticks in which no lumen can be found. In some instances, the external wall of the artery is smooth and even, but there often exists, around the thrombosed aorta, an intensive peri-arteritis which attaches the vessel to prevertebral fibrous tissues, encircling the neighboring veins and lymphatic ganglia, and reaching the fourth sympathetic ganglion and the chain above. The aortic wall often bears atheromatous plates which will hinder the completion of the operative treatment. In such cases, the aortic lumen often con-

tains a big moulded, organized clot, which extends upwards in the aortic cavity, without adhesion to the intima in the portion of the vessel above the level of the thrombosis

TREATMENT

One of us (Leriche) wrote, in 1923, that the ideal treatment of this condition, would be to resect the obliterated zone, and to bridge the vascular defect by graft. This could be accomplished if the thrombosis did not always strike the iliacs as well as the terminal aorta. In the present state of technic such an achievement seems impossible.

Nerve Supply Reduction Efforts have been made to improve the peripheral circulation, through reduction of vaso-constrictor nerve supply to collateral ways and to trunks below the obliteration, and an attempt has been made to stop the fatal spread of thrombosis, by *removal of the thrombotic zone*. At the same time, vasoconstrictor impulses which originate in the aortic wall and result in vaso-spasm in the still free channels, ought to disappear. Such a procedure finds its justification in the experiments carried out by one of us with his co-worker Stricker in 1933 on dogs.⁶ removal of the aortic bifurcation with its branches, with and without concomitant bilateral lumbar ganglionectomy. The latter condition produced gangrene, while the former yielded no severe troubles. With this objective in mind, we have performed bilateral ganglionectomies, and moreover resected the aorta and the obliterated iliacs.

Upper lumbar ganglionectomy Up to 1946, we have practiced the upper lumbar ganglionectomy in 14 cases, the lower in five. Upper lumbar ganglionectomy was preferred. First, because it seemed desirable to meet as few collateral arteries, which should at all costs remain intact, as possible. By a lateral approach, just underlying the last rib, one usually reaches the sympathetic chain without destroying any vessel of notable size. Second, because, in view of nervous action, it seems advisable to operate as high up as possible, in order to enlarge the lumbar arteries as well as those of the lower limbs. The results proved satisfactory in the long run. The following case history is an example.

Case 1 (summarized) (Leriche) Melv , 35-year-old male, complains of troubles in walking, and sexual impotency (total) for 3 years. Claudicatio intermittens (100 meters). Examination on June 5, 1936: severe global atrophy of both lower limbs. When legs raised to the vertical, legs and feet turn ivory white. No pulse felt anywhere in the lower limbs nor in the iliac fossae, nor on the midline, except above the umbilicus, where it is felt very strongly. No oscillations (Boulitte's apparatus) in the lower third, upper third of the leg, nor in the thigh. Very small oscillations close to Poupart's ligament. No trophic changes except on nail of left big toe. Provisional diagnosis: Aortic obliteration.

June 13, 1936 *Operation* Removal of first lumbar ganglion on the right side. Presence of an important number of large arteries in parietal muscles and in subperitoneal space. Owing to this, exposure of splanchnic nerve, which was originally planned, is given up.

THROMBOTIC OBLITERATION OF AORTA

Follow-up Patient out of bed on 3rd day Feels much better on operated side Discharged on 10th day

February 15, 1937 Demands to be treated for left side (same symptoms on left, as were formerly felt on right side cramps, cold fingers, small ulcerations around nails)

February 16, 1937 *Operation* Removal of 1st and 2d lumbar ganglia on left side Same operative findings as on opposite side Follow-up Heals per primam

In January, 1940 Feels well, does not suffer any longer in lower limbs, can walk longer But afraid lest he should suffer same trouble in his hands (feels cramps, cold, numbness, moderate pain)

May, 1940 Very good condition, warm feet, good trophicity, walks well Blood pressure 170/110 (this probably accounts for the symptoms in his hands)

Results are not always as good as in this case, nevertheless, one can say that patients always feel a functional improvement, and that some of them recover their sexual abilities

The objection to upper lumbar ganglionectomy as the sole operation is that owing to this high approach, one cannot have a near vision of the aorta, nor confirm the diagnosis, nor decide on the possibilities of an aortic resection We believe that aortectomy, whenever feasible, ought to be performed in order to check the spreading thrombosis, and to suppress arterio-arterial vaso-constrictor reflexes A point to be noted is that when the pathologic aorta has not been removed, patients often continue to complain of pain in the back This does not usually remain after aortic resection and is probably due to peri-arteritis

Having said that, we must acknowledge that the results of the bilateral lumbar ganglionectomy are good in the long run, if it is not performed too late In addition to Case 1, two of our patients, after three years, lead a normal life, except that walking ability is reduced, though improving year after year When this type of operation comes too late, there sometimes remains pain in a foot, intermittent pain which does not always hamper professional activities, but often compels the patient to take drugs at night The man, who pre-operatively could no longer sleep, and spent his nights in an arm-chair, is then able to sleep in bed He often remains liable to nightmares

—*Terminal aortectomy with bilateral lumbar ganglionectomy* The elaborate operation which consists in terminal aortectomy, removal of one lumbar chain, section of the other, the whole being performed through one single incision, is sometimes practicable We used it in the following case

Case 2 (summarized) (Leriche) G M, male, age 61, first seen in July, 1939, with the commencement of gangrene in right foot, and very severe bilateral pain *Claudicatio intermittens* for several years In 1936, noticed that right small toe became alternately white and blue, then, later on, painful at night, then, afflicted with a periungueal ulceration A surgeon performed bilateral perifemoral sympathectomy, with subsequent suppression of all symptoms, except claudication Improvement lasted for 2 years In December, 1938, pain in both feet His surgeon accomplished iterative periarterial sympathectomy—with subsequent aggravation Left foot remained painful, cyanotic, with black spot on 4th toe Exulceration of operative scar

Examination on July 8, 1939 Patient in bad condition, tired, but no severe symptoms in viscera B P 180/100 Normal upper limbs Lower limbs Emaciated, cold, cyanotic in their lower part, mostly on left side Torpid ulcer of operative scar on left

thigh On the generally bluish color of left leg and foot, one can see four small gangrenous spots On basal articulation of big toe, skin is necrotic, bordered by a torpid ulceration All toes are violaceous, the 4th bears on its tip a spot of dry gangrene Foot is icy cold, even under blankets Skin is dry and squamous Nails are thick and brittle Neither pulse nor oscillations up to the groin Both inner and outer sides of foot, show small veins which do not empty on pressure

Left lower limb shows same alterations, though less advanced Patient declares no erection for 10 years, not the least sexual concern

July 20, 1939 *Aortography* (under evipan anesthesia) Shows neat block of thorotrast shadow on edge of 3rd lumbar vertebra, from this point, there starts on left side a clearly-defined vessel which plunges into pelvis and gets lost there in numerous anastomoses One of these anastomoses (originating on right side), seems to fill the left internal iliac artery, and, through it, perhaps the external iliac, as one can perfectly well see small branches which seem to belong to the hypogastric system, and anastomose with branches from internal aspect of thigh The iliac circumflex is filled up on its whole course, and posteriorly, gets linked with two lumbar arteries On opposite side, the arterial network is less clear, more fragmentary, but of similar type The diagnosis is clear, the case seems beyond the possibilities of a bilateral lumbar ganglionectomy, in order to try and soothe the pain and stop the extension of the disease, an attempt at aortectomy is decided upon

Operation July 24, 1939 Left iliac incision Dissociation of external oblique muscle Section of internal oblique and transverse muscles Subperitoneal approach Easy removal of left lumbar sympathetic trunk (from 2nd inclusive to 4th ganglion inclusive) Exposition and dissection of terminal aorta, which is surrounded by a *very dense peri-aortitis* It is obliterated to a length of about 5 cm Once it has been dissected, first from sclerous fat, then from the vena cava, it is ligated at about 1 cm above the beginning of thrombosis Crushing the artery with the ligature is very difficult, as one gets the impression that the arterial wall will not give way, then, abruptly, the wall collapses and the ligature is tied The operator then follows the common iliac artery, carefully separating it from veins The common iliac artery is obliterated, the external iliac too, a pulse is felt in the internal iliac A ligature is tied just above the bifurcation of the common iliac artery The removal of the common iliac (right) is then begun Same findings as on opposite side Use of same procedure ligature above bifurcation of common iliac From then on, the aortic bifurcation lies between three ligatures Transection of left common iliac is troublesome, because of the presence of a hard calcified plate at this level Section is performed just above, the aorta is also cut across, and the whole is retracted upwards and overturned to the right, in order to separate the right common iliac artery from the vein Finally, section of right common iliac All this has been done without the slightest bleeding The right sympathetic chain is then looked for It seems impossible to progress on the external aspect of the vena cava, owing to a large collateral which lies there One passes under the vena cava, going from the midline to the external side of the column Section of the chain Local hemorrhage (stopped by muscle plug) prevents removal of 4th ganglion Parietal closure without drainage

Max B P Initial 180, terminal 170

On removing patient from table Both legs very warm, right foot warm, left foot warm, except on toes, which are cold

Same findings on evening of operation, toes move

On following day Same condition, but patient slightly listless

Right foot Normal temperature and color, no pain

Left foot Cyanosis extends Amputation is certainly necessary

August 6, 1939 Amputation at upper third of thigh Almost no bleeding from muscles Artery and vein are thrombotic Presence of many small vessels in posterior muscles

THROMBOTIC OBLITERATION OF AORTA

Dissection of specimen artery and vein, femoral and popliteal, are obliterated Microscopic study (Pr Gery, Strasbourg) "On the whole, arteries offer a picture of slow chronic endarteritis, the higher located, the more important and the more irregular The muscular wall is affected with widespread sclerosis, mostly on big trunks No media-verkalkung Larger veins Recent thrombo-phlebitis (from 10- to 15-day old) It is less and less advanced as one progresses distally Smaller veins chronic vegetating endophlebitis in numerous points Sciatic nerve no changes, no sclerosis"

Follow-up slow evolution of the amputation wound, as is the rule in such cases No inflammatory reaction, no infection At the end of August 1939, healing had hardly begun

Owing to war, to the evacuation of the hospitals of Strasbourg, and to subsequent events, we do not know what has become of this patient From our point of view, this does not alter the fact, that circulation in the right lower limb was considerably improved by aortectomy, with preservation of leg and foot on this side

Such an aortectomy with bilateral sympathectomy, has been accomplished a number of times since this case Cid Dos Santos in Lisbon had a patient who healed very easily, and, one year later, remained in excellent health Delannoy operated upon a 41-year-old woman in the first stage left lumbar ganglionectomy, in the second stage, transperitoneal aortectomy, very good result three years later, she could do her shopping herself, and even occasionally "enjoy a short run"³

One of us used a slightly different technique in his first case

Case 3 (summarized) (Morel¹³) Per , male, age 26, a truck driver Past history irrelevant Very good health First trouble two years ago suffered from "cramps" in legs, on walking and running, was treated by family doctor, for "sciatica" Suffered very intensely in both legs, could not sleep for nearly three months

Present condition Running is impossible Walking for a few hundred metres is stopped by very painful cramps Feels cold in the legs, even in bed Pain at night For past few weeks inability to reach a complete erection, coition hardly possible, ejaculation "unsatisfactory" Examination on February, the 12th, 1942 general condition seems good Both feet are cold, toes are marble-white (patient states they are such at any time, and this is one of his major concerns) No abnormal perspiration The anterior tibial, posterior tibial, popliteal and femoral pulses, not found, on either side Subjective symptoms more severe on the left In the upper extremities the left radial pulse is better felt, and stronger, than the right Oscillometry no oscillations at all in the legs, very minute oscillations in both thighs Blood pressure (left arm) 150/70 Normal heart No neurologic symptoms

Diagnosis Juvenile arteritis thrombosans, with probability of obliteration of the aortic bifurcation

February 16, 1942 Left lumbar sympathetic block—(nupercaine)— immediate warmth of foot, leg and thigh Feeling of warmth present for two days During these two days, can ride a bicycle with much rarer cramps No sexual improvement

February 20, 1942 Left lumbar block (nupercaine) progressive warming-up of originally marble-white foot, which becomes red (1st and 2nd toes last of all) Feels better for one day

February 23, 1942 Right lumbar block (nupercaine) apparently no immediate action, 20 minutes later, foot becomes very warm, and remains normal for two days

March 5, 1942 *Operation* Spinal anesthesia (nupercaine) Left iliac incision (subperitoneal approach) The sympathetic chain is very thin, but clearly recognizable Resection on 4 cms Dissection of the left common iliac artery, which looks abnormal, surrounded by a dense, reddish, adhesive cellulitis No pulse seen nor felt No blood

on puncture The artery is very much like a big, solid rope-like structure It is then resected (as high-up as possible towards the bifurcation) In the specimen brown-red adherent clot, thick walls, yellowish, brittle inner layer) Parietal closure layer by layer

Follow-up Warm limb immediately following operation (objective and subjective warmth) Patient leaves Clinic on 13th day

In the beginning short walks, perfect result on operated side no more cramps Then, with longer walks, feels cramps again, but less severe than before operation Above all, sexual condition much better Coition possible

May 2, 1942 Patient seen in consultation with Prof Leriche On this particular occasion (cold weather) left foot (operated side) is cold, right is icy Pr Leriche advises same procedure to be followed on opposite side

May 4, 1942 *Operation* (Morel) Spinal anesthesia Same approach as before, but on right side Easier dissection than on left side (cellulous adhesions less dense and less troublesome) Right lumbar chain is resected on 5 cm Then, the external iliac artery is found—a painstaking procedure, as it is a dry, rigid cord, about the size of a vas deferens Distal section as low-down as possible, upwards dissection, liberation of bifurcation of the common iliac artery The internal iliac seems to be thrombotic too, but, 2 or 3 seconds after it has been cut through, a severe bleeding occurs through its peripheral stump Digital compression on pelvic margin for a few minutes, then quick seizure of stump with forceps, and ligature Common iliac artery is then dissected about 3 cm, ligated as high as possible, and resected Abdominal wall closed by layers

Follow-up Back home on 12th day

August, 1942 Though all symptoms have not subsided, patient feels satisfied with present result First of all, he can enjoy a very active life does his job and drives a truck for most of the day, can walk about around his truck during loading and unloading Circulation better or worse, following rest or fatigue, but, on the whole, he feels much better than before operations Sleeps well, neither pain nor cramps in bed On exertion, feels from time to time cramps in the calves, but they are milder and of much shorter duration than before He states that sometimes, when walking is stopped because of a cramp, if he stops for a while, he is then able to resume his walk, with the feeling that he could go for miles without getting tired Psychic condition much better But the greatest improvement lies in the sexual abilities the erection is readily obtained and kept, coition is normally accomplished, as it was before the onset of the disease Potency but slightly diminished

Examination Both lower limbs are warm, feet are rosy No abnormal sweating

January, 1943 Patient gets married

July, 1944 the couple has a child

In January, 1946, patient states his good condition has undergone no change Works very hard

Pathology of specimen of left artery (Pr J F Martin, Lyon) "Endarteritis thrombosans with no specific histologic findings"

This is a very safe procedure The surgeon does not run the risk of a painstaking cleavage of a very adherent aorta, with subsequent severe shock But, on the whole, when feasible, removal of the pathologic aorta is preferable Such an operation was performed in the following case, with an excellent result

Case 4 (summarized) (Frich & Andre Morel)⁵ Vou , 43-year-old male, a solicitor, is first seen on December 22, 1943, complaining of severe impairment of walking Past history, irrelevant Moderate drinking habit Smokes heavily

Since 1 year, claudicatio intermittens, which becomes more and more severe (During winter preceding onset of disease, noticed that feet were usually cold though that winter was mild) At present, cannot walk more than 100 metres, without feeling a cramp

Patient consults Dr Gallavardin in Lyon, who diagnoses an arteritis of the lower limbs (April, 1943), and notes "no pulses in dorsalis pedis and posterior tibial arteries, pulse hardly perceivable at the groin Oscillometry maximal oscillations right ankle, 2 — left ankle $\frac{3}{4}$ of a division—right thigh 3 divisions, left thigh $1\frac{1}{2}$ division Dr Gallavardin notes on December, the 17th, 1943 "condition has become worse, no pulses felt in either lower limb"

Patient first examined by Dr Frieh on December, the 22nd, 1943 no pulses at all in both lower limbs aortic pulse, felt at the umbilicus

Oscillometry No oscillations at all Both feet are white and cold When put in dependent position, color is restored, but remains for several minutes even with feet raised above the horizontal No pain, no trophic changes

Sexual activity, reduced to nought Diagnosis probable obliteration of the aortic bifurcation

January 7, 1944 *Operation* Dr Frieh, Dr Morel Local anesthesia (procaine) Iliac approach (left side) The left iliac artery is exposed subperitoneally peritoneum is dissected up to the aortic bifurcation Exposure and dissection of the vessels are difficult, owing to adherent lymphatic channels and small veins The external iliac artery is ligated distally and cut through, then its posterior aspect is freed, a maneuver which leads to the internal iliac (obliterated), which after dissection of 2 cm, is ligated and cut through The common iliac artery is then freed upwards, the aortic bifurcation is exposed, and freed of posterior adhesions Same procedure is applied to the right common iliac artery, which is ligated distally as far as possible, and cut The aortic bifurcation does not "beat", a ligature is drawn just above, and tied A transverse section of the aorta is then performed just below the ligature (section through a very adherent clot) No bleeding at all The last two ganglia of the left sympathetic trunk are removed, a drain is left in the vascular bed

Follow-up Uneventful recovery, foot warm on evening of operation, remains such on following days On the 15th day, patient declares he has recovered his sexual abilities

March, 1944 *Operation* Ether anesthesia Right lumbar ganglionectomy Quick recovery

September 28, 1945 Patient in very good condition, lower limbs are warm, claudicatio intermittens still exists, but cramps appear only after 300 meters Good strength of lower limbs Considerable exertion possible, provided it be of short duration Patient has resumed all his professional activities Sexual abilities normal

We have used a procedure of this type many times since (Leriche), and we are very satisfied with it

Let us now try and see how the different types of operations should be used

THERAPY — INDICATIONS

The scheme we are trying to outline is not meant to represent the ultimate truth Our experience to date is of some value, as one of us happens to be among the men who have seen and treated the greatest number of patients afflicted with this too-little-known syndrome No doubt our ideas will be subject to change, as they have already gradually changed since the first of our cases But, at present, this is how we see the problem

Indications should be outlined in particular according to anatomical and clinical data in every case. Schematically speaking, patients can be divided in three groups.

1 Good Cases Patients who are still young, whose symptoms are essentially functional: fatigability of the lower limbs, disturbance of thermo-regulation thereof, genital troubles which are the more noticeable since they appear in full youth, obliteration of the bifurcation as demonstrated by clinical and oscillometric examination. Yet the tissue changes in the ischemic limbs, are still at their beginning: one could say they are liable to revert to the normal. At operation, the surgeon will find an easily cleavable aorta. The procedure will be completed without trouble on a good-risk patient.

Our opinion is that, in such instances, the surgeon should not hesitate. If everything seems suitable, after careful premedication, and, if judged advisable after a series of lumbar procaine blocks, the *ideal* operation will be preferred—through left subperitoneal iliac approach, dissection of external, internal and common iliac arteries, freeing of the bifurcation, and removal, in one piece, of the whole aortic bifurcation and of its obliterated subsequent branches. Removal of the left lumbar sympathetic chain. Depending upon each case, but depending mostly upon the abdominal bulk and general condition of the subject, the operator will merely perform the section of the right lumbar chain, just above the pelvic margin, or, if the right lumbar chain is left intact in this first stage because of the difficulties of its approach, a few days later, the right lumbar ganglionectomy will be performed through a right, subperitoneal iliac approach.

Thus, the maximum chance of immediate and long term improvement will have been given the patient, in a very short time.

Such a procedure is usually very well tolerated. If gently and methodically carried out, under spinal anesthesia, which greatly helps to retract the abdominal muscles and gives a perfect relaxation, it will be followed by a simple and uneventful recovery in these cases, which—and we stress this point—are *good cases*.

2 Medium Cases Patients are seen or diagnosed later in life: tired, thin subjects, whose circulation in the lower limbs is bordering on ischemia, patients aged over 40 and whose lower limbs begin to show trophic troubles, moderate but significant for the expert eye: meagre, marble-like feet, whose veins appear in hollow, small periungueal ulcerations, important callosities of the sole, striking atrophy of the muscles of the lower limbs. Blood urea rate is often a little above the normal, though the urinary output seems little affected.

In these cases, at operation the iliac arteries will be found to be embedded in a dense peri-aortitis, of which it will be very difficult to rid them. The bifurcation, above all, is stuck to the vertebral column, narrowly adherent to the vena cava. In these instances, considerable risk attends the complete freeing of the vessels and the removal of the thrombotic zone, *ie* danger of a vascular tear causing hemorrhage which it is impossible to check in a deep

wound containing fragile tissues, which break under the forceps, or danger of severe post-operative shock, which sometimes causes death, whatever the treatment

In these cases, we should advise the operation which, without severe risk, usually ensures a remarkable functional improvement in a first stage, by a high-located incision (underlying the 12th rib, without resection of the rib, which is not necessary), removal of the 1st and 2nd right lumbar ganglia. A few days later, large left iliac approach (subperitoneal), and as extensive removal as possible, of the left lumbar chain (at least 3rd and 4th ganglia). At this moment, it will be easy to expose the vessels, perhaps the "ideal" aortectomy will be feasible, but if this entails a risk, it will be deliberately abandoned. If the dissection of the external and internal iliac arteries seems easy, they can be resected on the left side. But, again, if the least difficulty is encountered in these fragile patients, the surgeon will remember that the margin is narrow, between the successful operation, and a disastrous failure. Above all, one must insist on the important point: the action on the sympathetic innervation.

3 Poor Cases Patients nearing 60, or adults seen in an advanced stage, patients emaciated through several months' suffering and insomnia, pale, listless at times. And especially patients who bear lesions of gangrene or pre-gangrene, such as those we described above. Such patients are dreadfully fragile. A careful medical preparation will be more than ever necessary, as well as a minute local treatment of the lower limbs in order to clean the ulcerations, to induce a subsidence of the lymphangitic processes, before any operation is attempted. At the time of operation, local anesthesia should be preferred, combined with a slow, atraumatic technic and a careful hemostasis. Following operation, rehydration, fulfillment of the metabolic needs of these subjects whose balance is always uncertain, are very necessary. And, sometimes, one will succeed in dragging back to life patients who seemed near their end.

What can be done with such patients? The great point is to divide the operative stages as much as possible: firstly, one should perform, on the side where the gangrene threatens most, a lumbar ganglionectomy through a high approach (in this way, one passes as far as possible from the dangerous zone and from the infected lymphatic ways), in a second stage, the opposite chain will be removed. If the condition of the patient improves sufficiently, it may be possible to use an iliac (low) incision and to perform at the same time the removal of the common iliac artery. Later on, this procedure will perhaps be feasible on the opposite side. Amputation of the definitive lesions of the extremities will thus be postponed as long as possible, the sympathetic and arterial operations will have improved the blood supply of the future amputation flaps, thus it will be possible to amputate at a lower site, than would have been practicable in the beginning. Healing will be infinitely better and quicker. When actual gangrene is present, amputation, preceded or followed by a lumbar sympathetic ganglionectomy, sometimes ensures a long survival.

A man, operated upon in 1932 (Leriche) (bilateral amputation at the thigh), still runs a garage, wheeling himself about in a special car. Another one, who underwent amputation on one side in 1939, had to be amputated on the other in 1947 (lumbar ganglionectomy had been unilateral).

On the whole, in instances so different, there should be no single way of proceeding, even if the general principles of therapy, as at present conceived, remain unaltered. These are: 1st, to improve the circulatory and trophic conditions, through distant sympathetic actions, and, secondly, to remove, whenever possible, the vascular lesions which are the origin of untimely pathologic reflexes.

Of the groups of patients which we have just endeavored to describe, one should remember that it is *time* which created them, time elapsed since the onset of symptoms, time lost in using minor therapeutic procedures or in overlooking the diagnosis. The syndrome is sufficiently clear-cut, to ensure an early accurate diagnosis, which allows an easy operation and an excellent cure. The study of all our cases leads us to the conclusion that, the earlier the necessary operation is performed, the better the results.

As regards the cases in which the pathologist discovers a thrombo-angitic origin, we feel more and more inclined to advise the performance of an adrenalectomy in addition to the aforesaid therapeutic measures. Adrenalectomy slows down or stops the progress of the disease. It is, as a rule, followed by an improvement in the general condition of the patient, with subsidence of the erratic pain which often teases those who underwent a plain ganglionectomy.

Contraindications. In view of the choice of the operation, let us insist on some contraindications, which are very important, because of the fragility of such patients.

—During the operation, no ligature should be tried nor trusted, on easily-breakable aortas, of the "chicken's trachea-type": no safety can be expected from this sort of vessel, and it is better to leave the thrombotic part untouched, without attempting any resection.

—No attempt should be made to remove the pathologic zone when there exists too dense a peri-aortitis, attempts at dissection "at all costs" often give birth to severe shocks.

—No operation should be undertaken in *cases seen very late*: emaciated, dehydrated listless patients, who will not stand anything, and who are doomed to die, whatever the treatment.

TECHNICAL DATA

Incisions. When we say *High incision*, we mean the type of incision we use for the surgery of the lumbar sympathetic ganglia, of the splanchnic nerve and of the adrenal (Leriche). The patient is disposed just as for an urologic lombotomy, the incision underlies the 12th rib and is parallel to it, cutting across the flank. The muscles are cut or dissociated (transverse), the

peritoneum is cleaved and retracted forward, and the lumbar chain is exposed in the bottom of the wound

The *Low* incision is that described by one of us with his associate Fontaine (*Presse Médicale*, Paris, 1933, No 92) curved incision, oblique inwards and downwards, nearing the iliac spine by two thumbs' breadth Aponeurotic and muscular sections as in a MacBurney's incision, except that internal oblique and transverse are cut across after they have been carefully separated from the underlying fascia The fascia will then readily be incised without opening the peritoneum, which is dissected from the internal iliac fossa and retracted towards the midline

For both these incisions, broad and curved retractors are necessary, we also advise the use, in addition to the scalytic light, of a portable projector, or spotlight, with parallel rays, which should be placed behind the operator's right shoulder, and which ensures a perfect vision of the deep planes

Hemostasis of the Aortic Section It seems best to insert, if possible in a normal zone above the thrombosis, or, if not, through the thrombotic zone, a sturdy braided silk ligature, which, for some time, will not slip Under cover of this ligature, a continuous suture of the aortic section with a curved atraumatic "intestinal" needle (same as for the closure of a duodenal stump in gastrectomy) will be accomplished with fine silk, and then a second continuous suture hiding the first row, in order to suppress all chance of leakage It is, of course, advisable to remove, after ligature and section of the aorta, the crushed clot which appears in its lumen and which would hamper the completion of the suturing process

Hemostasis of the section of the iliacs We insist upon the importance of always ligaturing a big vessel before its section, even if this vessel seems to be completely thrombotic and to no longer possess a lumen In our Case 3, the distal end of the internal iliac was thus the origin of an hemorrhage which could have been fatal We think that strong braided silk is the choice material for such a step

SUMMARY

- 1 A new pathologic syndrome, first described in 1940 (Leriche) is depicted, and special emphasis put on its clinical features
- 2 The evolution thereof is usually very severe, and operative measures should be preferred for its treatment
- 3 Case reports illustrate the possible therapeutic measures
- 4 Indications and contraindications in the treatment are discussed

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THE PROBLEM OF MAINTAINING THE CONTINUITY OF THE ARTERY IN THE SURGERY OF ANEURYSMS AND ARTERIOVENOUS FISTULAE

NOTES ON THE DEVELOPMENT AND CLINICAL APPLICATION OF
METHODS OF ARTERIAL SUTURE[†]

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It has long been recognized that the ideal method of treating aneurysms and arteriovenous fistulae involving important arteries is the extirpation of the lesion combined with some procedure which permits maintenance or reestablishment of the continuity of the affected artery. Although steady progress has been made experimentally in methods of suturing arteries, especially during the past half century, and although these methods have occasionally been used in patients, until recent years it has been the general feeling that such procedures were fraught with too great danger to make their use advisable in the surgery of aneurysms and fistulas in man.

The lateral closure of a wound of an artery by ligation antedates the experimental approach to the problem of vascular suture¹. Nevertheless, the principles which underly vascular repair, the precautions which must be observed, the hazards which are entailed, and the methods which are applicable were first established by experimental investigations. A number of authors, notably Watts,² Guthrie,³ Horsley,⁴ and Matas,⁵ have reviewed these contributions. In their papers one can find reference to those who have played an important part in this development—Asman, Gluck, v Horoch, Jassinowsky, Burci, Heidenham, Murphy, Silberberg, Napalkow, Dorfler, Salvia, Clermont, Dorrance, Abbe, Jaboulay and Briau, Payr, Bogle, Sahnari and Virdia, Thomaselli, Salomoni, Jensen, Amberg, Hubbard, De Gaetano, Reinsholm, Garré, Exner, Hopfner, Carrel, Guthrie, and others. Interest in the problem of experimental vascular repair has not waned and in recent years numerous papers have appeared describing these efforts. Among the recent contributions the demonstration by Murray⁶ that anticoagulants are helpful in preventing thrombosis is particularly noteworthy. Of all those interested in vascular surgery, the name of Carrel⁷ will always be held in especial esteem for, though excellent work had been done previously, his beautifully performed experiments, and those of his associates, did more than anything else to revive and maintain interest in the use of these methods.

Without minimizing the prime importance of these experimental studies, one is glad to give due credit to those who first applied the technics of arterial

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suture in man In 1759, Hallowell, following the suggestion of Lambert,¹ closed a small wound of the brachial artery by placing a pin through its margins, elevating the lacerated area, and tying a ligature about it According to Hopfner,⁸ and to Matas,⁵ the first successful lateral arteriorrhaphy in man after Hallowell's case was performed by Postempski, in 1886, when this surgeon succeeded in closing the rent in the femoral artery which he had accidentally made in draining an abscess Reports of other successful instances of lateral suture followed, and, by 1903, Hopfner was able to collect 30 reported cases⁸

The first end-to-end suture of an artery in man was reported in 1897 by Murphy,⁹ who, in a traumatic arteriovenous fistula, closed the small wound of the vein, resected the damaged portion of the artery, and accomplished a successful end-to-end anastomosis by invaginating the proximal into the distal segment Two additional successful operations utilizing Murphy's method were reported the same year by Pascha¹⁰ Thus, the first end-to-end sutures of arteries in man were done by means of the invagination technic of Murphy Subsequently it became apparent that direct approximation of the divided ends of the artery was a superior method

Not many years after the demonstration of Carrel, and his associates, that arterial defects could be successfully bridged by means of a vein transplant, this method was applied in a patient In 1906, Goyanes¹¹ treated a luetic popliteal aneurysm by proximal and distal ligation and reestablished blood flow by anastomosing the femoral artery to the distal end of the divided femoral vein and the proximal end of the divided popliteal vein to the distal segment of the popliteal artery Good circulation through the venous segment and into the popliteal artery was observed The foot maintained good circulation and a feeble dorsal pedal and posterior tibial pulse persisted during the six-day period of observation In 1907, Lexer¹² reported the case of a man with a traumatic axillary aneurysm resulting from the unfortunate efforts of a surgeon to reduce a dislocation of the shoulder, in which he excised the aneurysm and sutured a segment of saphenous vein into the arterial defect The patient died of delirium tremens on the 5th postoperative day Autopsy demonstrated the patency of the vein graft and of the brachial artery Lexer subsequently used this procedure in a few other cases In 1916, Bernheim reported the first successful case in the American literature¹³ He used a vein graft to bridge a defect in the popliteal artery following excision of a luetic aneurysm

In discussing Bernheim's paper, Halsted agreed that this was the ideal method of treatment and felt that the indications for it had been clear-cut in this case and the result excellent He referred, however, to a case in which six years previously he had asked Bernheim to carry out a vein transplantation after he had unavoidably sacrificed a segment of the popliteal artery in the course of excision of a sarcoma In this instance thrombosis in the vein segment had occurred He stated "The most serious objection to the 'ideal' or vein-grafting operation is perhaps this that in case of failure the thrombosis

which starts in the graft may extend either centrally or peripherally, or in both directions, from the interpolated vein into the artery and, thus, involve important anastomotic branches which would not have been threatened with occlusion if the artery had been merely ligated, or the sac merely excised or plicated. The transplanted vein is, consequently, a menace, for in at least two-thirds of the cases in which the 'ideal operation' has been practiced, thrombosis has occurred in the insert." To be sure, the hazard of thrombosis appeared to be greater after vein transplantation than after end-to-end suture or lateral arteriorrhaphy. Nevertheless, these remarks of Halsted, one of the most courageous of surgeons, and one who was vitally interested in experimental and clinical problems of vascular surgery, probably typify the skepticism which has existed as to the justifiability of such measures. Consequently, although the total number of clinical cases in which some type of reparative procedure has been performed has risen to a considerable figure, the method has been applied with relative infrequency.

I believe that it will be worth while to review my personal experiences with reparative measures in aneurysms and arteriovenous fistulae, because they confirm the general usefulness and reliability of these methods, emphasize certain difficulties in their application and certain causes of failure, and particularly because they demonstrate that the resolution of the surgeon to preserve the continuity of the artery whenever possible is the chief factor which determines the frequency with which such procedures will be carried out.

CLINICAL MATERIAL AND RESULTS

My experience with surgical treatment of aneurysms and arteriovenous fistulae includes about 300 cases. In a few aneurysms of the aorta or origin of the innominate artery, wiring and coagulation proved the only feasible method. In one innominate aneurysm and in 290 other lesions of peripheral arteries the more classical surgical means of extirpation were utilized. This report deals specifically with 34 cases in which some type of reparative procedure was accomplished. It does not include a number of other cases in which such procedures were considered and started but were abandoned because of various circumstances.

CRITERIA FOR SELECTION OF CASES

The criteria for the selection of suitable cases can be divided into two periods. In the beginning it was my practice to exclude all cases except those in which I could be relatively certain that normal arterial structures could be utilized and in which it appeared likely that the procedure could be accomplished without undue difficulty. If only the cases are considered in which the lesion involved those arteries upon which the main blood supply to a part is dependent and in which repair is most desirable—the innominate, common and extracranial portion of the internal carotid, subclavian, axillary, brachial, iliac, common femoral, femoral, and popliteal—I find that I performed only four reparative procedures in 138 such cases (2.9 per cent). I then deter-

mined to carry out a repair in every instance in which this could possibly be performed without sacrificing collateral arteries and without leaving *in situ* obviously badly damaged portions of arteries. This altered approach resulted in the repair of arteries in 30 of the last 57 cases (52.6 per cent). Included were a small number of cases in which the outcome of the procedure appeared questionable to me at the time of operation because of the degree of local damage or the presence of infection, as will be pointed out later, this group includes practically all of the failures. Repair was undertaken in these instances in the hope that some might be successful and in an effort to test the limits of applicability of such methods. I did not fear difficulty from extension of any thrombus which might occur because of the excellence of the collateral circulation.

Although I believe that the attitude of the surgeon is of paramount importance in the application of reparative procedures to the surgery of aneurysms and fistulae, the anatomic situation which one finds at operation often precludes such measures. In the first place, there may be thrombosis of the distal artery. This occurrence has made impossible any arterial repair in a number of my cases. I presume that very extensive arterial obliterative disease will sometimes make such procedures impossible. Since most of my cases have been traumatic in nature, this factor has not been important. In one case of rather extensive medionecrosis of the popliteal artery a successful vein graft was performed. In traumatic lesions extensive damage to the artery is often a determining factor in preventing the restoration of continuity, at least by the simpler means such as lateral arteriorrhaphy or end-to-end anastomosis. In contrast to the limited injury to the artery which is the rule when aneurysms or fistulae have resulted from stab wounds, for example, there is generally extensive injury when these lesions have resulted from shell fragments, land mines, or bullets, as was the case in almost all of my patients. There is frequently gross and much more often microscopic injury to the artery, not only in the immediate neighborhood of the aneurysm or fistula but some distance from it. Whether the damage which is evident only on microscopic examination is a real threat to successful arterial repair, only further experience will tell. In the cases of arteriovenous fistula the simpler means of repair, such as ligation or transfixion of the fistula, lateral suture, or end-to-end anastomosis, often cannot be applied because of the extent of local trauma. In my experience the majority of the arteriovenous communications were not simple fistulae but were associated with one or several saccular aneurysms as well. Sometimes these saccular aneurysms arose from the veins or from the fistula itself, but many of them originated in the artery. Obviously, in the latter cases a segment of artery must be excised and, unless the ends can be so mobilized that they can be approximated, the only means of restoring continuity is by a vein transplant.

A very common finding which has made it seem unwise to perform an end-to-end suture or a vein graft, has been the presence of some important collateral artery so near the end of the undamaged portion of the vessel that

it would have had to be sacrificed in order to make such a repair possible. Except for the rare cases where the local situation makes it evident that continuity of the artery can be safely maintained by some simpler procedure, such as ligation or transfixion of a fistula, it seems clear that definitive surgery should not be attempted unless there is good evidence that the collateral circulation is satisfactory. Knowing that the collateral circulation was apparently adequate and that it depended in part upon these collateral vessels to which I

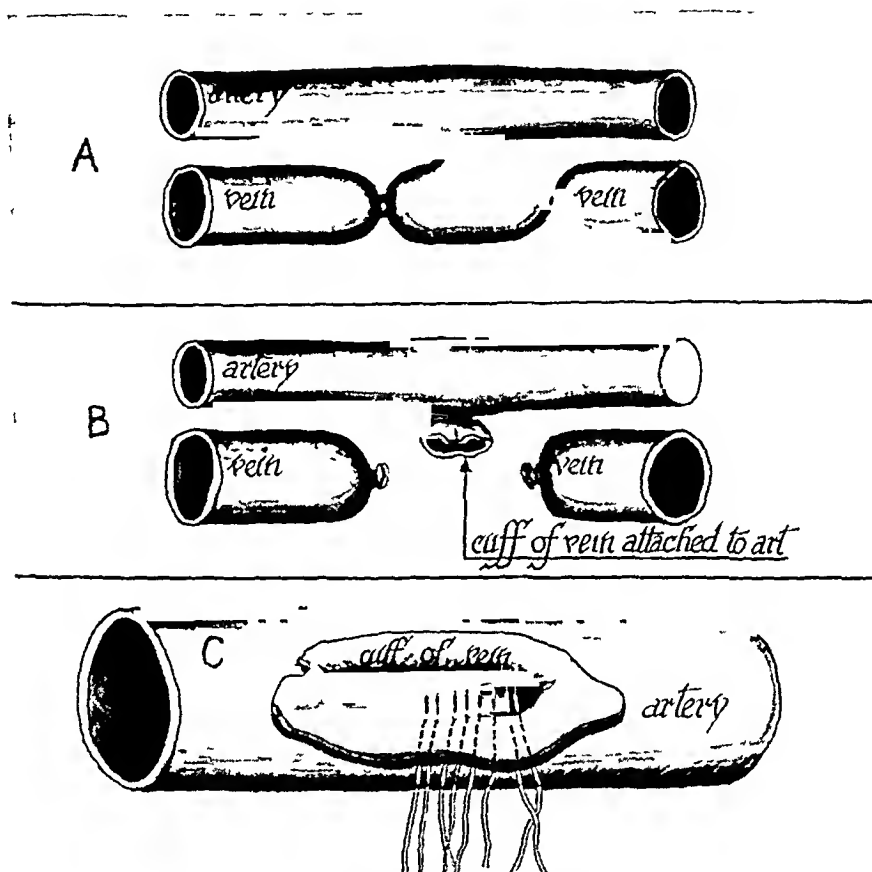


FIG 1—Methods of Repair of Arterial Defect in Arteriovenous Fistula

(A) The fistula has been ligated with silk at its origin from the artery. A transfixing ligature is next placed.

(B) The vein has been divided above and below the fistula and the ends transfixed. The cuff of vein will now be plicated so as to reinforce the ligated fistula.

(C) Method of lateral suture. A cuff of vein is left attached. The suture is accomplished with interrupted mattress sutures.

have referred, I have felt it unwise to sacrifice any of them. I did not reexamine the collateral circulation with these collateral arteries temporarily occluded, a procedure which I feel, in retrospect, might have made repair of the artery justifiable in a number of cases in which it was not attempted. I have not felt that associated nerve lesions requiring suture were a contraindication to arterial repair. In these cases the nerves have been dissected free, the aneurysm or fistula has been excised completely or subtotally, and the arterial

repair accomplished Following this procedure the necessary nerve suture has been performed

METHODS OF REPAIR

In the present series of cases four types of repair have been carried out—ligation or transfixion of the fistula, lateral arteriorrhaphy, end-to-end suture, and vein transplantation In one instance an arteriovenous fistula was simply ligated and transfixed In others the fistula was ligated, transfixed, and buttressed with a segment of the divided vein (Fig 1, A and B) In cases of lateral suture the freshened edges of the rent have been stripped of adventitia and approximated with interrupted mattress sutures (Fig 2) In performing

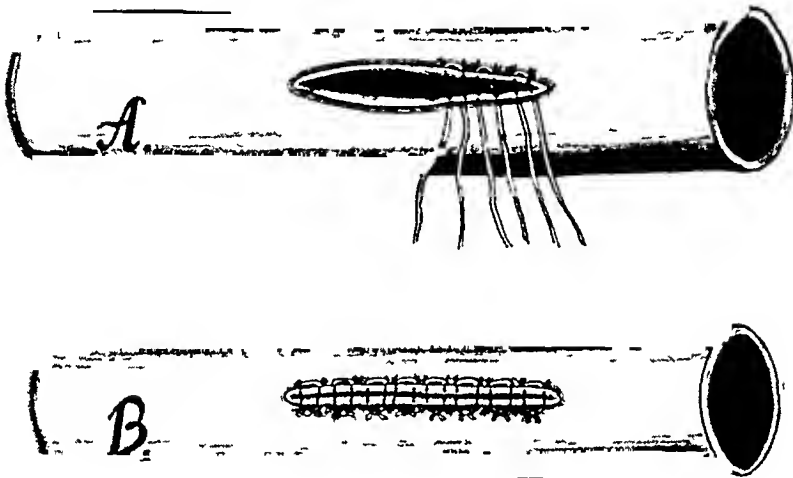


FIG 2—Method of Lateral Arteriorrhaphy The edges of the defect are approximated with everting mattress sutures

lateral suture in cases of arteriovenous fistulae a cuff of vein has been left (Fig 1, C) and this has been used to reinforce the closure In end-to-end sutures four evenly spaced mattress sutures have been placed and have been used as traction sutures for the placing of other everting mattress sutures in order to complete the anastomosis (Fig 3) A similar technic was used in vein grafts (Fig 4) The segment of vein was reversed so that the proximal end of the vein was sutured to the distal end of the artery and *vice versa*, thus guarding against difficulty with any valves which might be present in the insert In all types of repair the adventitia was carefully stripped off and the vessels were washed out with saline and kept moist with liquid petrolatum or saline solution Rubber-shod serrafine artery clamps were used for temporary occlusion of the vessels Fine straight or curved artery needles were employed Since silk sutures were not available, No 120 cotton sutures were used This suture material is about as fine as No 5 zero silk When vein grafts were used the venous segment was excised from an accessible vein of suitable caliber In cases of arteriovenous fistula in which a ligation of the fistula was not performed the affected segment of artery and vein, together with the fistula, was

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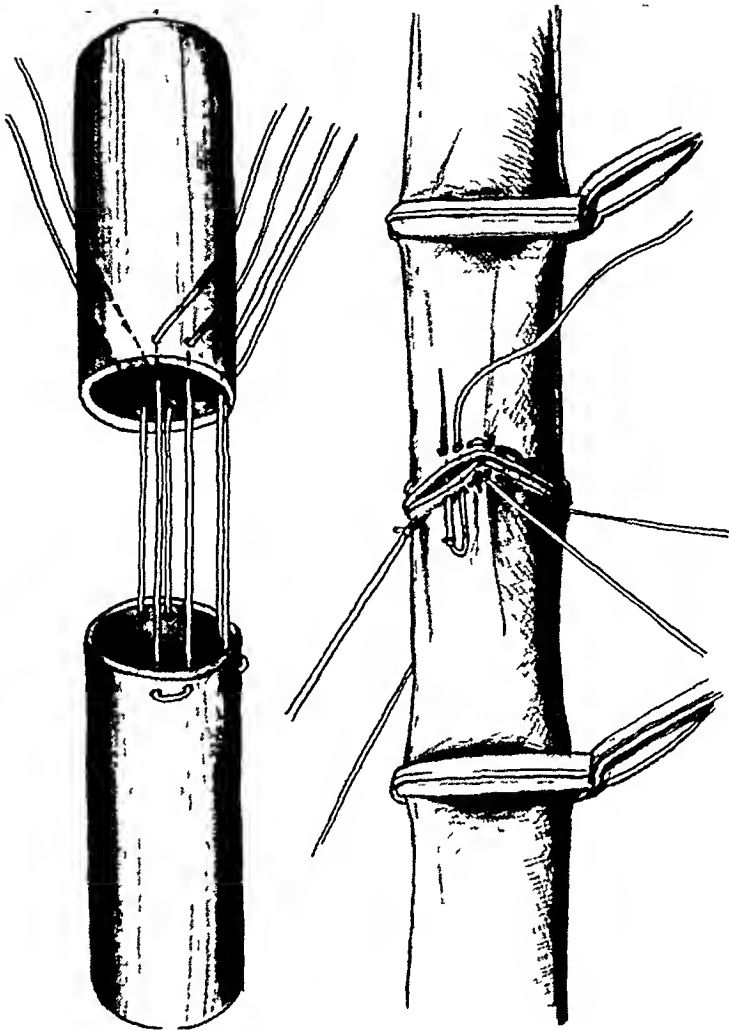


FIG 3—End-to-end Suture Four mattress sutures are placed through the ends of the vessels at equidistant parts Traction upon these converts the cylindrical ends of the vessels into a square, with the intima everted Closure is completed with additional interrupted mattress sutures

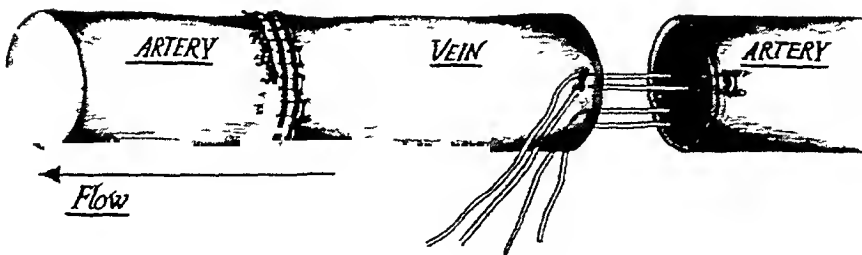


FIG 4—Vein Transplantation The vein has been sutured with interrupted mattress sutures to the distal end of the artery Suture to the proximal end of the artery has been started

excised. Some of the arterial aneurysms were completely excised. In some, the sac was opened after dissection and temporary occlusion of the artery proximal and distal to the aneurysm, following which the sac was completely or subtotally resected. All involved peripheral nerves were freed and identified before excision of the sac wall.

Anticoagulants were used in most cases of lateral suture, end-to-end suture, and vein graft. Except in those instances in which an adequate prothrombin

TABLE I—*Cases of Arteriovenous Fistula Treated by Ligation and Transfixion of the Fistula*

Case No	Age of Patient	Duration of Lesion in Mos	Location of Lesion	Pre-operative Sympathectomy	Estimated Diameter of Fistula in Mm	Anticoagulant Therapy	Period of Post-operative Follow-up in Mos	Result
1	36	9	Carotid at bifurcation	0	3	0	1 5	Excellent
2	31	4	Common carotid	0	10	0	1	Excellent
3	22	4 5	Common carotid	0	5	0	1	Excellent
4	26	9	Popliteal middle 3rd	+	7	0	4	Excellent except for slight ankle edema
5	35	9	Popliteal middle 3rd	+	5	0	1	Excellent
6	19	6	Popliteal distal 3rd	+	6	+	2	Excellent except for slight ankle edema
7	45	10	Popliteal middle 3rd	+	5	0	1	Excellent
8	20	9	Femoral middle 3rd	+	5	+	1	Excellent
9	27	11	Femoral proximal 3rd	+	8	0	1	Excellent
10	25	6	Femoral proximal 3rd	0	4	+	1	Excellent
11	32	7	Femoral proximal 3rd	+	5	0	1	Excellent
12	23	7	Femoral proximal 3rd	+	3	0	1 5	Excellent
13	21	4 5	Axillary distal 3rd	0	3	0	1	Fistula recurred in 2 days. Excised 2 weeks later with good result

level had been obtained by preoperative administration of dicumarol, 50 mg of heparin was given intravenously as soon as the decision to attempt repair was made, and was continued at intervals of four hours until a suitable response had been obtained from dicumarol. In the majority of cases dicumarol was continued for three weeks. Often a small amount of fibrin foam was placed in the wound. This seems to help in hemostasis and does not jeopardize the vascular suture. The use of anticoagulants is discussed in detail in another paper.¹⁴

In some cases, sympathectomy had been performed before operation in an effort to increase the efficiency of the collateral circulation.¹⁵

RESULTS

The essential data are summarized in Tables I to IV. In these tables the cases have been segregated according to the method of repair employed. In Table I are listed 13 cases in which the fistula was ligated and transfixed and the continuity of the artery maintained. In Case 13 a simple ligation and transfixion was performed, in all the others the fistula was ligated and transfixed at the point of its emergence from the artery and was buttressed by a segment of the divided vein. The ages of the patients ranged from 19 to 45 years. The duration of the fistula at the time of surgery ranged from 4 to 11 months. The fistula was between the carotid artery and the jugular vein in three instances, between the popliteal vessels in four, the femoral in five, and the axillary in one. In eight cases sympathectomy had been performed because of poor collateral circulation. Anticoagulants were used in three cases. In Case 6 heparin was given at the time of operation and until a satisfactory prothrombin level had been obtained from the administration of dicumarol. In the other two cases dicumarol had been given preoperatively for several days. In all three, dicumarol was continued for from two to three weeks. In a fourth case (Case 13) a single dose of heparin was given at the time of operation.

The size of the fistula varied, the diameter ranging from 3 to 10 mm. I was surprised to find that even large fistulae could be ligated close to their origin from the artery without causing any demonstrable narrowing or distortion of the artery. In six cases saccular aneurysms were present. These sacs arose from the vein in three cases, from the fistula in two, and from the artery in one. In the latter case the sac had a small neck which could be ligated and transfixed. Case 10 was complicated by a fracture of the femur and Cases 4 and 6 by peripheral nerve injuries requiring suture. In the one, neurorrhaphy was done at the time of operation, in the other it was deferred until a later date.

In Case 13 in which simple transfixion of the fistula was performed, recurrence of the bruit and thrill was evident two days after operation. The fistula was excised with quadruple ligation two weeks later, with good result. The result was excellent in all the other cases. There was no evidence of recurrence or of dilatation of the artery. The two limbs were of equal warmth and color except in those instances in which sympathectomy had been performed; in these patients the affected foot was warmer than the other. All the pulses distal to the site of anastomosis were present and full, and were judged by all observers to be about equal to those in the contralateral extremity. The results of oscillometry were approximately the same in the two extremities except for two of the cases in which the limb had been sympathectomized, where oscillations were slightly greater upon the operated side. There were no abnormal physical findings except in two cases in which there was slight edema of the ankle which became progressively less with the passage of time.

In Table II are listed data on five cases in which an arterial defect was repaired by lateral suture. The patients were all in their twenties; their

vascular lesions were of from 25 to 65 months' duration at the time of operation. Two were instances of traumatic arterial aneurysm, three of arteriovenous fistula. The brachial artery was affected in one case, the subclavian in two, and the femoral in two. In none of the patients had sympathectomy been performed. The arterial defects were from 3 to 12 mm in length. The artery appeared in good condition in three cases, fair in one, and rather poor in one. There was only slight constriction of the artery following

TABLE II—*Cases in Which Artery Was Repaired by Lateral Arteriorrhaphy*

Case No	Age of Patient	Duration of Lesion in Mos	Type of Lesion	Location of Lesion	Lgth of Arterial Defect in Mm	Condition of Artery	Degree of Constriction	Anti-Coagulant Therapy	Period of Follow-up in Mos	Result
1	27	25	Saccular aneurysm*	Brachial distal 3rd	4-5	Good	Very slight	+	2	Excellent until hemorrhage on 13th P O day. Reexploration. Excision and ligation with good results.
2	25	36	Saccular aneurysm	Subclavian distal 3rd	3	Good	Very slight	+	25	Excellent. Hematoma evacuated on 10th post-operative day.
3	20	6	A-V	Subclavian distal 3rd	12	Good	Very slight	0	17	Excellent
4	27	6	A-V	Femoral proximal 3rd	12	Fair	Slight	0	17	Excellent
5	29	65	A-V	Femoral middle 3rd	12	Poor	One-half diameter	0	1	Poor. No pulse felt distally after operation. Reexploration in 3 hrs. Segment thrombosed. Excised with good result.

* Grossly infected. Had ruptured subcutaneously.

repair in all cases except one, in this case the diameter of the artery was reduced by 50 per cent. Heparin was given for two days in Case 1, in Case 2 it was given until the prothrombin level had been rendered satisfactory, in this case dicumarol was continued for 11 days.

In Case 1 the artery was bathed in a pool of pus. Continuity of blood flow through the artery was maintained, but on the 13th postoperative day a hemorrhage occurred through the sutured defect. On reexploration there was no evidence that healing had taken place at the line of suture. The segment was excised and the artery ligated, with good result. In Case 5 the extent of damage to the artery and the narrowing of its lumen after closure of the defect were so extensive as to make me wonder at the time whether the segment should not be excised. Shortly after operation it was evident that thrombosis

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had occurred. The thrombosed segment was excised, with good result. There had been no propagation of thrombus either centrally or peripherally. This patient did not receive anticoagulant therapy.

In the other three cases an excellent result was obtained. The color, warmth and pulses in the two extremities were the same. The results of oscillometry were equal in the two limbs in one case and moderately reduced on the operated side in one, in the third oscillometric studies were not made.

TABLE III—Cases in Which Artery Was Repaired by End-to-End Suture

Case No	Age of Patient	Duration of Lesion in Mos	Type of Lesion	Location of Lesion	Pre-operative Symp	Length of Artery Excised in Mm	Period of Follow-up in Mos	Result
1	20	5 7	Saccular aneurysm	Brachial, distal 3rd	0	1 5	2	Excellent
2	35	7 5	Saccular aneurysm	Brachial, distal 3rd	0	1 5-2	2	Excellent
3	27	8	Saccular aneurysm	Brachial, proximal 3rd	0	1 5-2	3 5	Excellent
4	28	8 5	Saccular aneurysm	Brachial, middle 3rd	0	1 5	2	Excellent
5	23	5 5	Saccular aneurysm	Axillary, distal 3rd	+	2-2 5	2	Excellent
6	19	6	Saccular aneurysm	Brachial, middle 3rd	0	1 5	2	Excellent
7	24	6	Saccular aneurysm	Brachial, distal 3rd	0	2	1	Segment thrombosed Good circulation
8	21	3	Saccular aneurysm	Brachial, distal 3rd	0	2	5	Probably thrombosed and recannulized
9	29	3	A-V and saccular aneurysm	Axillary, distal 3rd	0	2	4	Excellent
10	29	3	A-V	Femoral and profunda arteries Femoral vein	0	3-femoral 2-pro-funda*	2 5	Excellent

* Anastomosis between proximal end of profunda and distal segment of femoral artery

In Table III are listed data upon ten cases in which the artery was repaired by an end-to-end suture. The patients ranged in age from 19 to 35 years. The lesions varied in duration from 3 to 8 5 months. Eight of the patients had an arterial saccular aneurysm, two had an arteriovenous fistula. In one of these there was a saccular aneurysm in addition to the fistula. The lesion involved the brachial artery in seven cases, the axillary in two, and in one a double fistula was present between the femoral and the profunda femoral arteries and the femoral vein. In one patient sympathectomy had been performed before operation.

It was necessary to excise segments of artery ranging from 1 5 to 3 cm in length. In lesions of the axillary and brachial vessels length of artery was gained by adducting the arm to the body and flexing the forearm upon the arm. After completion of the operation, position of the extremity was maintained by the use of elastic bandages or by means of plaster splints. In one

case in which the fistula involved both the femoral artery and the profunda, the divided ends of the femoral artery could not be approximated. It was, however, possible to approximate without tension the proximal end of the profunda to the distal stump of the femoral artery (Fig 5). In five patients there were injuries of peripheral nerves which required lysis, and in two of them neuro-rhaphy was necessary.

The patients were followed for a period of from 1 to 5 months. In eight of the patients there was every evidence to substantiate the patency of the artery. In one case (Case 7) trauma to the brachial artery had resulted in an aneurysm near its distal end. The sac lay partly in the belly and tendon of the biceps muscle. After its excision it was feasible to suture together the divided ends of the artery. The artery was small and its distal segment was somewhat scarred. Further resection of the distal end, in order to have available for suture more normal artery, was impossible because the vessel

TABLE IV—*Cases in Which Continuity of Artery Was Restored by Vein Transplant*

Case No	Age of Patient	Duration of Lesion in Mos	Type of Lesion	Location of Lesion	Pre-op Sympathectomy	Lgth of Vein Graft in Cm	Source of Vein Graft	Period of Follow up in Mos	Result
1	26	4 2	A-V and sacular aneurysm	Femoral distal 3rd	0	2	Saphenous	3	Excellent
2	19	5	A-V	Femoral middle 3rd	0	2	Branch of femoral	3	Excellent
3	26	4	A-V	Femoral distal 3rd	+	5	Saphenous	3	Excellent
4	35	?	Saccular aneurysm	Popliteal, middle 3rd	+	2	Small saphenous	4	Excellent
5	36	6 yrs	Saccular aneurysm	Femoral proximal 3rd	0	2 5	Femoral	1 5	Excellent
6	24	5 3	Saccular aneurysm	Brachial middle 3rd	0	2 5	Saphenous	1 2	Thrombosis Good circulation maintained

bifurcated nearby. This patient received heparin at the time of operation and was started on dicumarol shortly afterwards. By mistake he was given very large doses of dicumarol during the afternoon and night, though no signs of bleeding appeared the anticoagulants were discontinued and vitamin K was administered. Evidence of thrombosis of the sutured segment was soon noted, though the hand maintained good circulation. In another patient (Case 8) the anatomic condition seen at operation was similar to that in the preceding case, indeed, the damage to the distal artery was more extensive. Although the patient continued to have a good radial pulse, the ulnar pulsation and oscillometric readings were significantly reduced. Some observers felt that the anastomosis had remained patent, but it was my belief that thrombosis had occurred and had, perhaps, been followed by recannulization.

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In Table IV data are given concerning six patients in whom an arterial defect was repaired by vein transplantation. The patients ranged in age from 19 to 36 years. Their vascular lesions were traumatic in origin in five cases, in one a saccular popliteal aneurysm had resulted from medionecrosis of the artery. The traumatic lesions were from four months to six years in duration. Three were instances of arterial aneurysm, three of arteriovenous fistula. In one case there was a saccular aneurysm in addition to a fistula. The brachial artery was involved in one patient, the popliteal in one, and the femoral in four. Sympathectomy had been performed in two cases. The vessel for grafting was taken from the main saphenous vein in three patients, from the small saphenous in one, from the femoral in one, and from a branch of the femoral in one. One patient had a fracture of the femur, and in another neurolysis and neurorrhaphy were necessary. All the patients were given anticoagulants.

The patients were followed for a period of from five weeks to four months. The patency of the vessels was demonstrated by various studies in five cases, in the sixth thrombosis occurred but good circulation was maintained. No explanation is evident for the failure except that the suture may have been technically imperfect because of the small size of the artery. I have not seen such a small brachial artery in any other case. Arteriograms taken of several patients demonstrated patent vessels and showed no postoperative dilatation of the venous insert. In those cases in which the vein had been larger than the artery, the arteriograms demonstrated the relative diameters of the vein transplant and the artery to be much the same as they were observed to be at operation (Fig 6). In those cases in which the artery and vein were observed to be approximately the same size at operation, arteriograms taken later showed their relative diameter to be unchanged (Fig 7).

It was evident that reparative procedures had been successful in 28 of the 34 cases. In one case (Case 13, Table I) a fistula recurred, and in one case of lateral suture in the presence of gross infection (Case 1, Table II) healing did not follow. In one case of lateral suture (Case 5, Table II), in one case of end-to-end suture (Case 7, Table III), and in one case of vein transplantation (Case 6, Table IV) thrombosis of the repaired segment oc-



FIG 5—Arteriogram of Case 10, Table III. A fistula between the femoral and profunda femoral arteries and the femoral vein has been resected with end-to-end suture of the profunda artery proximally to the femoral artery distally. Arteriogram taken ten weeks later by injection of 70 per cent diodrast into the common femoral artery reveals excellent filling of the femoral artery. No narrowing is noted at the suture line.

curred In one case (Case 8, Table III) several observers had some doubt as to the outcome I felt that thrombosis and subsequent recannulization had taken place

In analyzing these failures, I feel, in retrospect, that the first patient should have been treated differently—instead of a simple double transfixion of the fistula, the vein should have been divided and used to reinforce the transfixed fistula, as was done in other cases There is much to suggest that



FIG 6

FIG 7

FIG 6—Arteriogram of Case 2, Table IV An arteriovenous fistula between the femoral artery and vein has been resected with transplantation of a segment of a large branch of the femoral vein, about 2 cm in length, in order to bridge the arterial defect Arteriogram taken seven weeks after operation reveals the vein insert and the artery to have relative diameters about equal to those observed at completion of operation

FIG 7—Arteriogram of Case 1, Table IV An arteriovenous fistula and saccular aneurysm involving the femoral vessels has been resected and a segment of saphenous vein, 2 cm in length, introduced as an insert in the arterial defect There was no dilatation of the venous segment at completion of the anastomosis and none is noted on arteriogram taken ten weeks later

ligation of vessels in continuity is, in general, unwise and that division of ligated vessels is preferable The one exception in which I feel that simple multiple transfixion gives excellent results is in the case of patent ductus arteriosus in which the technic of Blalock has proved a simple and generally reliable method¹⁶ In this situation, in contrast to others, the anatomic factors perhaps favor success of the procedure The ductus is actually not as long as

it appears to be when stretched out by dissection, and once ligation is accomplished the pulmonary artery and the aorta naturally fall back into close proximity, thus, eliminating stretching and tension of the ligated fistula. In regard to the second case in which the aneurysm was grossly infected, I know of no alternative procedure which would have made successful healing of the artery more likely. In three cases I feel that the local damage to the artery was sufficiently extensive to account for the thrombosis which ensued. The lateral suture in Case 5 in Table II should probably not have been carried out—instead the damaged segment should have been excised and repair accomplished by end-to-end suture or vein graft. In addition, anticoagulants should have been used. In the other two cases further resection of the injured distal segment of artery appeared to be prohibited by the proximity of the point of bifurcation to the severed distal end of the vessel. In the remaining case (Case 6, Table IV) I know of nothing that could have been done to ensure success. The vessel was unusually small and it is possible that the repair was not technically perfect, although at the time of operation it appeared to be satisfactory and a free flow of blood through the vein insert was present at time of closure.

In addition to the complications in the cases just discussed there were a few others. One patient had a postoperative hematoma which required exploration of the wound two hours after the original operation (Case 2, Table IV). The vein graft was found to be functioning well and the bleeding to be coming from a small branch to a muscle. This was clamped and ligated. Three other patients had hematomas of the wound (Case 2, Table II, Cases 2 and 4, Table IV). All were being given anticoagulants. In one the hematoma was aspirated, in two the wound was reexplored, and in both there was evidence that diffuse capillary bleeding had occurred. Anticoagulants were stopped, and no further difficulty was encountered. Two patients (Cases 4 and 5, Table IV) had a mild wound infection which did not interfere with the success of the vascular repair.

In evaluating the patency of the repaired artery various examinations were utilized. The presence of a warm, well-colored foot was obviously not sufficient evidence upon which to judge the repair to be successful, nor was the presence of distal pulsations. The presence of a radial pulse after brachial or axillary repair or of a dorsal pedal pulse after a femoral or popliteal repair is of little significance, for such pulses may be present after ligation of main arteries proximally, provided the collateral circulation is adequate. The presence of *all* pulses distal to the site of repair, equal in volume to those of the contralateral limb, is felt to provide evidence of successful maintenance of continuity of the artery. For example, when full popliteal, posterior tibial and dorsal pulses are present after repair of the femoral artery, the patency of this vessel is apparent. In addition, criteria of success included visible patency by arteriograms in those cases in which such studies were made, and oscillometric results comparable to those in cases in which the patency of the artery was

ation, and at a time when blood flow through the affected artery was intact, none of the patients had any appreciable decrease in tolerance of exercise. In contrast, those patients in whom surgical treatment had necessitated ligation of a major artery as a rule had fatigability. For example, those with ligated popliteal or femoral arteries could walk only an average of about seven-tenths of a mile before onset of extreme fatigue or cramps in the calf.¹⁵

DISCUSSION.—The ideal method for the surgical treatment of aneurysms and arteriovenous fistulae is extirpation of the lesion and maintenance or restoration of the continuity of the artery. In this regard it is fitting to pay tribute to Lambert who, in 1759, long before arteries had been repaired in man or in experimental animals, conceived the idea of preserving the involved artery. At his suggestion, as I mentioned previously, Hallowell accomplished closure of the small rent in an artery by twisting a thread about a pin placed through the lips of the wound. In a letter to Hunter, which was read on June 15, 1761,¹⁸ Lambert stated after discussion of a patient who was left with some functional impairment following treatment of an aneurysm by proximal and distal ligation: "This case, in particular, made me turn my mind to the operation for the aneurysm, and made me wish to see it done with some alteration in the method, so as to make less disturbance in the circulation of the part. I recollected all that I had seen or read of the effects of styptics, of pressure, and of ligatures in the case of hemorrhage. I considered the coats and motions of arteries, and compared their wounds with the wounds of veins, and other parts. I reflected upon the process of nature in the cure of wounds in general, and considered, in particular, how the union of divided parts was brought about in the operation of harelip, and in horses' necks that are bled by farriers. Upon the whole, I was in hopes that a suture of the wound in the artery might be successful, and if so, it would certainly be preferable to tying up the trunk of the vessel." Unfortunately, his brilliant reasoning was to wait long for additional application while surgeons struggled with the technical difficulties of curing aneurysms and fistulae without undue risk of life and while the fundamental principles of vascular suture were being developed.

Such reparative procedures can be carried out in a large number of cases. Though local anatomic factors sometimes preclude the use of these methods, the attitude of the operator determines, perhaps more than anything else, the frequency with which these procedures will be applied. A high degree of success can be anticipated, nevertheless, up to the present time one cannot assume that the results of arterial repair will be uniformly successful.

Since this is the case, it is advisable to do everything possible to make certain that the collateral circulation is adequate before definitive surgery of the aneurysm or fistula is attempted. An exception can be made in the rare case with poor collateral circulation in which the local findings at operation make it evident that the continuity of the artery can be maintained by some very simple means, such as transfixion of a fistula. Even though arterial repair is planned and accomplished, the same care should be exercised to

preserve all collateral arteries as is essential when methods are used which necessitate ligation of the affected artery. If a collateral vessel requires division in order to complete repair, the collateral circulation should be rechecked and its adequacy established with this vessel temporarily occluded. I feel that employment of this principle would have increased the number of reparative operations in the present series of cases.

The chief hazards of surgical repair of arteries are hemorrhage, thrombosis, and subsequent development of aneurysmal dilatation at the site of repair. The chief local factors which endanger the success of the repair appear to be damage to the wall of the artery, infection, and such small caliber of the lumen as to make accurate approximation difficult. Most important of all, in the success of the operation, is careful observance of the well-established principles of surgical repair of vessels.

In the present series of cases postoperative hemorrhage occurred only once, in a case in which the sutured artery lay in a pool of pus and in which healing did not take place. Some of the early, and recent, investigators have demonstrated that successful repair can be accomplished in the presence of infection. Nevertheless, from the earliest experiments it has been recognized and repeatedly demonstrated that the danger of hemorrhage and of thrombosis is increased by infection.

In my experience thrombosis has occurred in only three cases of lateral arteriorrhaphy or end-to-end suture in which the local arterial damage was sufficiently extensive to raise doubts in my mind at the time of operation that the artery would remain patent, and in one vein transplant to an exceedingly small brachial artery. In retrospect, I feel that a wider excision and vein grafting would have been a preferable procedure in the former cases and would have been applicable in at least one of them. As mentioned previously, thrombosis in the last case may have resulted from imperfect technic due to the small size of the vessel, although the completed anastomosis appeared at the time of operation to have been properly performed. In the introduction to this paper I quoted some remarks of Halsted on the danger of extension of the thrombus so as to compromise important collateral arteries. I believe that clinical and experimental data suggest that such propagation of a thrombus is unlikely provided the collateral circulation is adequate, for extension of a thrombus is not apt to occur if the circulation proximal and distal to the site of repair is kept active by collateral blood flow. Furthermore, the chance of thrombosis occurring, or of its propagation if it should occur, can be lessened considerably by the use of anticoagulants. In the reported series there was nothing to suggest extension of the thrombus in those cases in which thrombosis did take place. In the one case in which the occluded segment was excised the thrombus was sharply limited to the immediate area of the repair.

There was recurrence of an arteriovenous fistula in one case in which the fistula was simply transfixated and ligated in continuity, a procedure which appears to be unwise. As far as I know, up to the present time no aneurysms have developed at the site of repair. Should this unfortunate event take place,

it appears likely that it would occur within the first few weeks or months after operation, as it did in Holman's case,¹⁹ and not years later when atherosclerotic changes might add an additional hazard to its extirpation. Under such circumstances it would seem that the original procedure could still be looked upon as justifiable, such patients should be able to withstand surgical cure of the aneurysm with no more risk than would have been entailed had the artery been ligated at the original operation.

In any vascular repair certain principles must be followed. The artery must be handled gently to avoid local injury, its intima must be kept moistened with saline solution or mineral oil, the artery must be occluded only by some nontraumatizing means such as rubber-shod artery clamps, and the adventitia must not be allowed to fall into the suture line. The edges of the vessel must be carefully brought together with fine suture material in such a way as to approximate intima-to-intima. Strict asepsis must be maintained. These principles gradually became apparent in the course of the early experiments. Most of them are evident from the early work of Jassinowsky,²⁰ Murphy,⁹ and Dorfler,²¹ and they were exemplified in the experiments of Carrel and Guthrie.²² Some disagreement existed as to the choice of suture material, but it has long been established that only the finest nonabsorbable sutures should be used. Silk has been almost universally used, but the present study demonstrates that also very fine cotton sutures are satisfactory.

In order to facilitate the accurate approximation of the inverted intima, Carrel suggested the use of three initial tension sutures placed at equidistant points.²³ Horsley⁴ suggested the use of a metal bar for holding the three traction sutures. In the cases I have reported, four interrupted mattress traction sutures have been used, because it was found easier to space four sutures at equal distance from one another than three. The use of four traction sutures was a contribution of Frouin.²⁴

Practically every type of suture has been recommended. Jassinowsky²⁰ used interrupted sutures, Burci²⁵ a continuous suture. Both tried to avoid inclusion of the intima, as Crafoord²⁶ still does in his cases of coarctation of the aorta. Others, however, have largely abandoned the idea, since the work of Silberberg,²⁷ Napalkow²⁸ and Dorfler,²¹ most workers have included the intima in the suture. Jaboulay and Briau²⁹ introduced the use of interrupted everting mattress sutures. Clermont,³⁰ working with veins and Dorrance³¹ with arteries, used a continuous mattress suture. Horsley⁴ recommended a continuous cobbler's stitch. In the present series of operations I have used interrupted mattress sutures. Although I have found both continuous and interrupted, plain and mattress sutures to be satisfactory in experimental animals,* I have felt that the everting mattress sutures gave one greater assurance

* Since completion of this paper a statistical study of the complications following end-to-end suture of arteries in dogs suggests that everting mattress suture technics are superior to those in which the ends of the vessels are approximately layer-to-layer with plain sutures.

(H B Shumacker, Jr and R I Lowenberg: Experimental Studies in Vascular Repair. I. Comparison of Reliability of Various Methods of End-to-End Arterial Suture Surgery. In Press.)

of accurate intimal approximation without interposition of adventitia and that such anastomoses could be accomplished without noticeable constriction. In repair of peripheral arteries the vessels can be easily and securely closed with interrupted sutures, in certain situations, however, continuous sutures are preferable. For example, the continuous mattress suture, which Blalock³² has recommended for subclavian-pulmonary anastomosis in congenital heart disease where there is impaired pulmonary blood flow, is the suture of choice since it gives one the best opportunity to secure a tight closure and, since once the anastomosis is completed, the posterior portion of the suture line is relatively inaccessible for any further repair which would be necessary should a leak be present.

Up to this point I have not mentioned the use of mechanical aids in the repair of arteries. The use of permanent nonabsorbable intraluminal prostheses, such as the glass rods of Abbe,³³ is doomed to failure from thrombosis. The removable glass splint of De Gaetano³⁴ is obviously better. The soluble rod technic recently presented by Smith³⁵ can undoubtedly be used with success, but I have felt no need for intraluminal splinting and have preferred the more classical methods of repair. A number of external aids have been introduced in order to permit sutureless anastomoses. The absorbable magnesium ring technic of Payr³⁶ had extensive experimental and some clinical trial and has some merit, as have the modified rings of Lespinaee, Fisher and Eisenstaedt.³⁷ Recent attention has been directed to nonsuture methods by the ingenious vitallium tubes which Blakemore, Lord and Stefko³⁸ have used successfully. I have preferred suture technics because of several considerations. The sutured vessel has no permanent rigid, nonabsorbable, partially constricting ring around it as does the vessel repaired by the vitallium tube method. I believe in the hands of those experienced in vascular suture, the suture method carries less risk of subsequent hemorrhage and no significantly increased hazard of thrombosis. Though I have had little experience with the nonsuture method, I have attempted to use it in a number of cases but have abandoned it in each case because of certain difficulties. In some I had trouble in finding a vein of suitable size, in others I could not use the tubes because their length would have necessitated occlusion of collateral vessels near the end of the severed artery. In one case in which I completed a vein graft by this method, a brisk hemorrhage occurred as the wound was being closed, which was due to slipping of the tube out of the proximal artery even though it had been tightly ligated in place with several silk ligatures. Undoubtedly, this brief personal experience is not representative of that of workers who have devoted more attention to this technic. It is my feeling, however, that those who are confronted with problems of vascular repair can more profitably devote their energies to obtaining proficiency in vascular suture rather than in nonsuture methods. Perhaps the nonsuture method has its greatest sphere of usefulness in the hands of the untrained vascular operator who, on rare occasions, may encounter a case requiring anastomosis of blood vessels.

The question of establishing the patency of the artery after vascular repair

deserves some comment. From the earliest reports to the most recent, one finds that there has been a tendency to judge the results of repair of arteries to be successful on extremely uncertain grounds. Some observers have used the absence of gangrene or other ischemic damage as evidence of success. Regardless of the incidence of gangrene in cases in which a given artery is ligated, the absence of such a disaster does not prove in any case that the repair has been followed by persistent patency of the repaired segment. Others have cited good warmth and color and a palpable dorsal pedal or radial pulse as evidence of success, observations which may follow the ligating of main stem arteries if the collateral circulation is adequate. If by success we mean preservation of the lumen of the repaired vessel, we must be careful to obtain good evidence of its patency, a matter which has been discussed previously.

One also finds in the literature numerous statements to the effect that if a vascular repair remains patent for only a short time, it may be useful in tiding the patient over a precarious period until the collateral circulation becomes well-established. Should thrombosis occur gradually over a period of time, with slow narrowing of the lumen, one might expect this occurrence to favor development of collateral circulation, just as a partial proximal ligation seems to exercise such an influence. Actually, I know of no work to suggest that such thromboses bring about slow gradual occlusion of arteries, on the contrary, when thrombosis occurs it seems generally to be rapid and complete. One can imagine that in a badly traumatized limb some of the collateral channels might be functioning poorly because of compression from hemorrhage into fascial compartments and by attendant vasospasm. In such a circumstance, if a repaired artery could be kept open for a few days it might serve a useful protective purpose. In most circumstances, and certainly in the surgery of aneurysms and fistulae, one can look upon an arterial repair followed by thrombosis as having served no useful purpose. It has, indeed, subjected the patient to certain additional hazards, hazards which, however, as I have previously pointed out, are minimal and of little practical concern provided the collateral circulation is adequate, no collateral vessels have been destroyed, and anticoagulants are used.

Altogether there seems every justification for performing reparative or restorative procedures instead of arterial ligation whenever such methods can be applied. The recent report of Freeman³⁹ is in agreement in this regard. Brooks⁴⁰ has stressed the advisability of arterial repair in cases of arteriovenous fistula during a period when many of his contemporaries have recommended other measures. It is fair to say that the results of successful repair in cases of aneurysm or fistula are superior to any method which necessitates sacrificing the continuity of the affected artery.

SUMMARY

1 Thirty-four cases in which the continuity of the affected artery in cases of aneurysms or arteriovenous fistulae was maintained or restored by some method of vascular repair are reported.

- 2 The methods of repair, the choice of cases for application of such methods, and the results in successful and unsuccessful cases are discussed
- 3 The historical development of the principles of vascular repair and of their clinical application is reviewed briefly

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CONSERVATIVE SURGERY IN TUMORS OF BONE* WITH SPECIAL REFERENCE TO SEGMENTAL RESECTION

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IN recent years there has been a growing tendency on the part of those who treat neoplasms of bone, both benign and malignant, to rely more upon surgical measures and less upon roentgen therapy. The employment of the latter for tumors that are known to be radioresistant is at present restricted largely to inoperable cases or to those few patients who will not consent to surgery and it is conceded that the objective is palliation rather than cure. We know that worthwhile relief from pain and restraint of tumor growth may often follow the intelligent use of roentgen therapy.

With the present increasing preference for surgical measures there appears to be a definite trend in the direction of conservatism, especially in respect to the mutilating procedure of amputation. This does not mean that amputation is no longer regarded as the safest and most justifiable operation for the great majority of primary malignant tumors of bone. Rather it implies that in the past perhaps too little attention was paid to the possibility of selecting cases that might yield satisfactory results by a technic which, while it eradicated the disease locally, preserved all or most of the extremity and a good measure of function as well.

After devoting considerable thought to the possibilities inherent in procedures less radical than amputation we presented our conclusions in a paper, "Conservative Surgery in Tumors of Bone", delivered at the Southeastern Surgical Congress in 1941. Further experience has but tended to strengthen our recorded convictions relative to the following:

(a) that there is a definite place for selecting a conservative rather than a more radical operation,

(b) that there are criteria which enable one to make a correct decision in the majority of instances,

(c) that there is a measure by which the surgeon can subsequently determine whether his initial decision was justified, and

(d) that if judgment is exercised the patient stands to benefit rather than to suffer from the surgeon's conservatism.

On the other hand, it would be regrettable if ill-considered and injudicious extension of conservative measures should lead to an over-enthusiastic adoption of less radical procedures, especially in circumstances where the latter offered a greater likelihood of a cure.

DEFINITION OF CONSERVATIVE SURGERY

For the purpose of this discussion we would define conservative surgery as an elective operation which either avoids amputation entirely or which

* Read before the New York Surgical Society, May 14, 1947

places it at a lower level with greater prospects of improved function. As an example of the first, one might cite total excision of a scapula to avoid an interscapulothoracic disarticulation, and as exemplifying the second, the selection of an upper thigh level of amputation for a tumor of the lower femur—this in contrast to a hip-joint disarticulation. Other examples will be cited later.

FACTORS IN FAVOR OF A CONSERVATIVE PROCEDURE

In general one may state categorically that benign tumors almost always call for conservative measures. Tumors of border-line or of unquestioned, although low-grade, malignancy deserve consideration relative to the possibility of a less mutilating procedure than amputation. Here, other factors will often decide the proper selection.

Tumors which are medullary in origin and which do not appear to have penetrated through the cortex to present beyond the periphery of the bone are more prone to respond to a less drastic operation than amputation. On the other hand, typical "run-of-the-mill" osteogenic or chondro sarcomas, or those of great bulk, with wide extension beyond the normal confines of the bone and of high malignancy as determined by histologic study, are definitely unsuited to a conservative attack.

When considering the suitability of a more conservative approach the following criterion should be used: "Can the tumor together with sufficient tissue to prevent a local recurrence be completely removed, and if so, can a useful limb be maintained?" Once the decision to avoid an amputation has been made and the less mutilating measure carried out, subsequent events will prove the wisdom of the choice. Providing there is never any local or regional recurrence it may be regarded as having been a justifiable one even though distant metastasis ultimately occurs, for in the event of the latter even an amputation at the highest possible level would not have afforded any additional protection. However, if a local recurrence takes place then the choice may be regarded as having been ill-advised.

DESCRIPTION OF CONSERVATIVE PROCEDURES

1 *Curettage* This is a widely used method of treatment for the following: Giant cell tumor, bone cyst, enchondroma, fibrous dysplasia and other lesions found beneath the cortex. By its means one can deal successfully with many benign tumors which formerly were sometimes subjected to amputation. The curetted cavity is usually cauterized with saturated solution of zinc chloride and irrigated thoroughly with saline before closure of the wound.

We have one five-year survival of a chondromyxosarcoma of the upper tibia in which after microscopic examination a curettage and bone graft was done deliberately, the patient remains well five years later with no evidence of a recurrence or metastasis.

In Case I, the procedure here would ordinarily have been thigh amputation.

2. *Partial Resection.* The acceptability of the principle of partial resection for benign bone tumors needs no further comment. Although for truly malignant tumors this measure may seem hazardous, in selected cases we believe it is indicated.

In support of this concept we cite a case of endothelioma of the upper fibula; and another of the lower fibula (Case II). In Case III both have remained free of disease for more than five years following partial resection of the fibula. Another noteworthy result of resection occurred in a pedunculated chondrosarcoma of the lower femur. In Case IV there was preservation of a normal limb and freedom from symptoms.

Owing to the prominent and virtually subcutaneous position of the clavicle, tumors which arise in this bone may be diagnosed more promptly and dealt with by partial or even total resection more readily than those having their origin in most of the other long bones. It is surprising how slight a functional impairment results even when the entire clavicle is removed.

3 *Segmental Resection and Massive Bone Graft to Repair Defect:* While the proper setting for resection of bone sarcomas is seldom encountered it would seem that surgeons have made little effort to utilize the measure even when an opportunity presented itself. Phemister stands almost alone among the living American surgeons who have made a determined effort to apply resection to carefully selected cases of primary sarcoma of the long bones. Indeed, he quotes figures from the records of the Bone Sarcoma Registry of the American College of Surgeons to show that of 701 cases of osteogenic sarcoma, only three of the 93 five-year survivals were treated by resection, and only one by resection and bone transplantation.

On the other hand, Phemister has practiced resection of the tumor-bearing segment and bone transplantation to replace the defect, in at least ten cases, not all of which have as yet been reported. Anyone who has studied Phemister's series must be impressed with the rare judgment he displayed in the selection of his cases combined with his technical skill in carrying out the extensive procedures. His series includes the following remarkable successes—a ten-year survival of a patient with a resected osteogenic sarcoma of the upper right humerus who is still able to practice his profession of dentistry; an eight-year survival following resection of the upper five inches of the tibia for chondrosarcoma, a 12-year survival of a chondrosarcoma of the humerus treated by local excision and roentgen therapy. Even more remarkable are two femur cases that were treated by resection and utilization of massive transplants from both tibiae, one, a borderline giant cell tumor of the medial condyle remains well for three years and ten months after operation; the other, a central chondrosarcoma of low-grade malignancy remains well for four and one-half years after operation. One cannot refrain from extolling these results which demonstrate the valuable place held by resection in the treatment of borderline or slowly-growing malignant tumors.

Our experience with segmental resection and massive bone graft is limited to three cases, two of these involved removal of the middle third of the

humerus (Case V and Case VI), and in one (Case VII) the middle third of the ulna was resected. The lesions for which these operations were required were, thrice recurrent central chondroma, twice recurrent fibrous dysplasia, and fibrosarcoma of low grade malignancy. The latter two cases are too recent to consider from the standpoint of end result. The first case, on the other hand, is well 11 years, with an excellent functional and anatomical result.

4 *Excision* Some extremity bones may be completely excised together with the tumor, resulting in preservation of the limb and often only moderate functional impairment. This procedure may be applicable not only to benign tumors but to selected malignant ones as well. In the case of the latter, the more low-grade the malignancy the better the ultimate outlook—an observation applicable to more mutilating operations too. In this connection we would cite a case of chondromyxosarcoma of the scapula in which a partial and subsequently a total scapulectomy was followed by freedom from disease for a period of 11 years (Case VIII). In another noteworthy case (Case IX) total scapulectomy succeeded in eradicating a huge chondromyxosarcoma, however, later there developed pulmonary metastasis and a small local recurrence. The same result was noted in a case of angioendothelioma of the scapula (Case X) in a child, however, without local recurrence.

Owing to the extreme rarity of tumors of the patella, an opportunity to excise this bone is seldom afforded. However, in a case of malignant giant cell tumor of the patella (Case XI) an excellent local result was obtained, while pulmonary metastasis finally caused the patient's death three and one-half years later there was complete absence of local recurrence and during most of the interval between the operation and death, she was able to continue her work as a machine operator.

5 *Amputation* At first, it may seem paradoxical to refer to an amputation as a conservative surgical measure, in a sense of course it is not. What is meant here is the substitution of a less radical for a more radical amputation, with the result that the patient is thereby better able to care for himself, to earn his living and to enjoy a more normal existence.

Reference to certain surgical texts reveals the usual admonition, *ie*, never to amputate for bone sarcoma through any portion of the bone involved. This, then, implies an obligatory hip disarticulation for all cases of osteogenic or chondro sarcoma of the lower end of the femur—a site in which the disease is most frequently found. We have long been convinced that with a careful selection of cases a high thigh amputation will prove an acceptable substitute in many instances. A recent study of 39 consecutive cases of osteogenic and chondro sarcoma of the lower femur in which a high thigh amputation was performed at Memorial Hospital in lieu of a hip-joint disarticulation, discloses that in 37 cases no stump recurrence took place, of the two in which this did occur (Case XII), one underwent a disarticulation at the hip and remained well for more than five years when last traced. Thus, in only one instance, or approximately 3 per cent, was the patient's chance of a survival theoretically diminished. On the other hand, 37 patients were afforded a sufficient stump

to provide them with an artificial limb and to remove them from the group of prospective crutch-users for the remainder of their lives. This we regard as useful conservative surgery.

In another patient with a sarcoma of the lower fibula (Case XIII), the knee was preserved by an amputation performed five inches below the knee-joint. the survival period here is more than ten years.

Perhaps the most impressive case is that of a man (Case XIV) who had an osteogenic sarcoma of the proximal phalanx of the fifth finger of the right hand. Amputation of the fourth and fifth fingers and parts of the ulnar side of the hand left him with a useful member which enabled him to continue his occupation as a bus driver. he has remained well for nine years.

CONCLUSIONS

Conservative surgery for tumors of bone implies the substitution of some less radical procedure than amputation or if the latter is unavoidable, amputation at the lowest level compatible with safety.

Curettage, partial resection, segmental resection and excision are methods which may at times be used in lieu of amputation. If these procedures are successful in eradicating the primary tumor and in avoiding a local or regional recurrence, they may then be considered as wholly justified.

Certain histologic types and certain clinical and roentgenographic settings indicate the advisability or the inadvisability of attempting conservative measures.

High thigh amputation for osteogenic and chondro sarcoma of the lower femur may in selected cases be a safe substitute for hip disarticulation and offers greater advantages to the patients who survive.

It would seem to be worthy of our concentrated effort to perfect the operative treatment of bone neoplasms by every available means. One important advance might be the exercise of better care in the selection of cases in which less radical surgery would accomplish complete removal of the tumor with less mutilation, thus affording the patient a better opportunity to lead a more normal life.

CASE REPORTS

Case I.—M. K., female, age 31 years, was admitted on November 17, 1941, complaining of pain in the right knee of five weeks' duration. Examination revealed a slight swelling on the anterolateral aspect of the upper tibia. Operation November 19, 1941, curettage of the tumor-bearing area of upper tibia and sliding bone graft from mid-tibia. Pathologic diagnosis, low-grade myxochondrosarcoma. November 13, 1946, five years later patient presents no evidence of disease and films reveal a satisfactory appearance which has remained unchanged in the past four years. Function of the knee is unimpaired, an excellent result.

Case II.—W. B., male, age 14 years, was admitted on September 14, 1938, with a history of having injured his right knee in October 1937 while playing football. This was followed in a week by the appearance of a swelling in the region of the head of the fibula which slowly increased. On biopsy the pathologist reported endothelioma or small spindle cell osteogenic sarcoma but favored the former. Accordingly, the lesion was

treated with high voltage X-rays, a total of 1200R Units, delivered to each of three parts (anterior, posterior and lateral), and, in addition, the lower half of the fibula received 1200R Units through a lateral port. On November 21, 1938, the upper half of the fibula was resected and on pathological examination showed no evidence of residual tumor. January 18, 1946 the patient reports that he is symptom free.

Case III—B C, male, age 22 years, was admitted on July 23, 1941, complaining of a lump on the outer aspect of the lower leg above the ankle. Doctor Ewing's diagnosis



FIG 1A—Case 3 Endothelioma of fibula

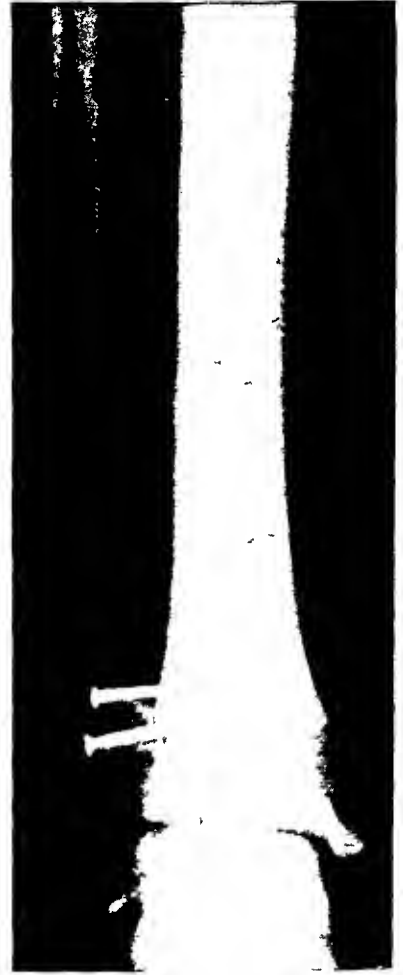
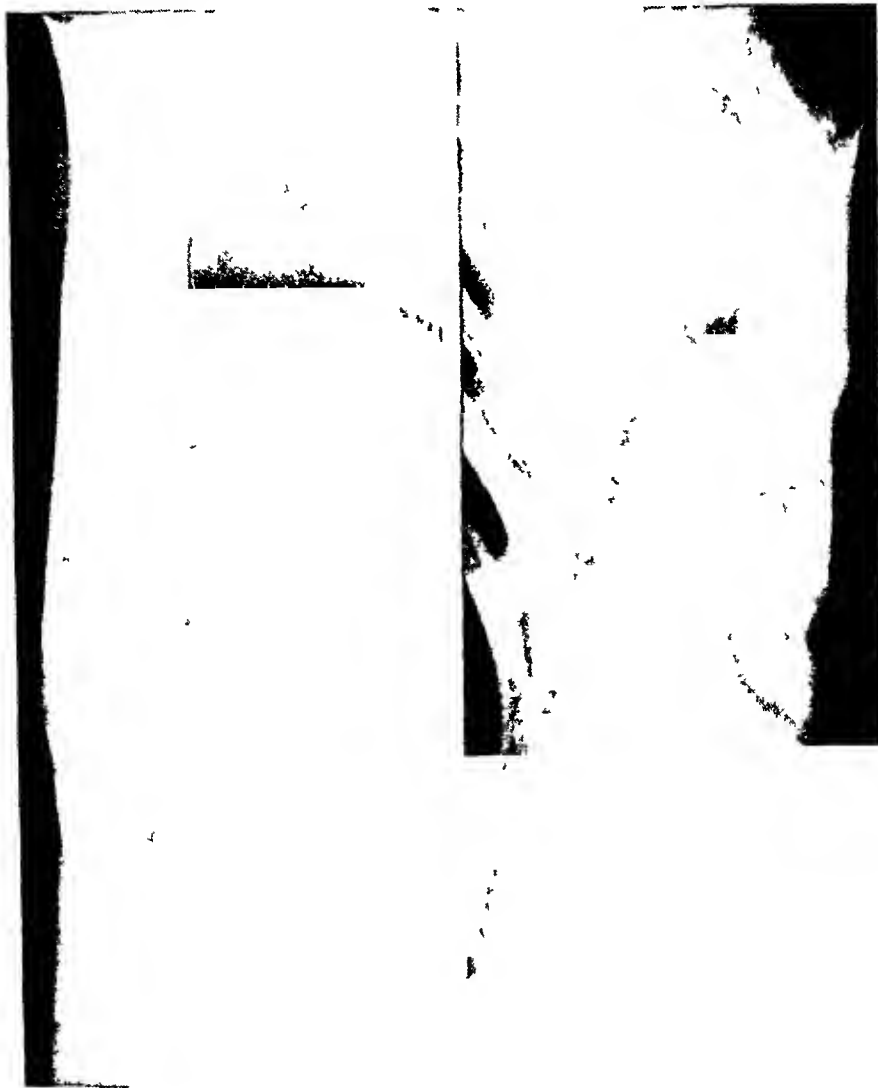


FIG 1B—Five years after radiation therapy followed by segmental resection of fibula

on a specimen obtained from a previous biopsy done elsewhere, was that of Ewing's sarcoma. Roentgen therapy was also given prior to admission. Operation, June 12, 1941, excision of lower fourth of fibula, stabilization of mortise with two vitallium screws. Pathologic diagnosis: bone radiation changes, but no residual tumor found. July 31, 1946, five years later, vitallium screws have been removed, there is a well-healed scar and excellent function of the left ankle (Fig 1).

Case IV—H B, female, age 40 years, was admitted on April 4, 1937, complaining of swelling of the left thigh, of two years' duration. Examination revealed an ovoid tumor, 8 x 9 cm, over the anterolateral aspect of the lower left femur. Sections from a previous biopsy performed elsewhere were reviewed by Doctor Ewing who confirmed the diagnosis of chondrosarcoma. Operation, April 5, 1937, excision of pedunculated tumor and primary wound closure. Pathologic diagnosis: osteogenic sarcoma, chondro type, very low-grade. April 2, 1946, nine years later, patient reports she has no complaints and has a full range of motion in the involved lower extremity.



A B
FIG 2A —Case 5 Central chondroma of humerus Before operation
FIG 2B —Recurrence after third operation

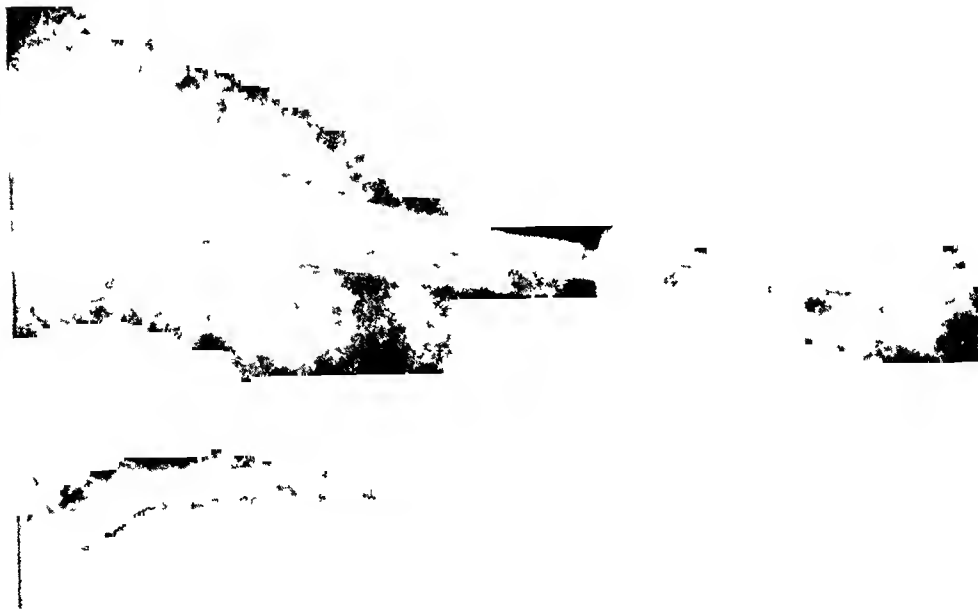


FIG 2C —After segmental resection and massive tibial transplant to replace defect.

Case V—A C, female, age 27 years, was admitted on September 13, 1930, with a history of pain in the left arm of four years' duration. Examination revealed enlargement of the mid-portion of the left humerus, and roentgenograms disclosed a central radiolucent area, irregular in shape, occupying this portion of the bone. Conservative attempts (curettage), at removal were made in October, 1930, July, 1931, and in June, 1934. While the histologic report in each instance was that of benign central chondroma, each operation was ultimately followed by a return of symptoms. Accordingly, on February 18, 1937, a segmental resection of the mid-portion of the humerus, including the tumor-bearing area, with a safe margin on either side, was carried out, the resected portion was replaced by a massive tibial transplant mortised at either end (see Fig 2C). This transplant ultimately united and the final result is shown in Fig 2D). The patient is now well ten years since the resection during which interval she has been able to continue her work as a stenographer (Fig 2).



FIG 2D—End result 9 years later showing complete consolidation of the transplant

Case VI—D F, male, age 30 years, was admitted on December 21, 1939, complaining of pain in the right shoulder, of twelve months' duration. He gave a history of three episodes of traumatism to this area followed by pain. After the initial incident a fracture through a bone cyst was revealed. On examination, the right arm appeared swollen over the mid-portion. There was pain on attempted motion in any direction. The left arm had

been amputated following an accident at the age of eight. The diagnosis following an aspiration biopsy on January 3, 1940, was that of "wall of bone cyst." Operation on the same date consisted of curettage of the cyst and implantation of a bone transplant from the tibia. Fairly satisfactory bone regeneration took place and the patient remained well until June 5, 1943, when on account of a recurrence of symptoms, a second operation was performed. This paralleled the first one. There was an additional period of three years of freedom from symptoms, followed by a recurrence and roentgenographic evidence of reactivity. A segmental resection was performed on April 8, 1946, a massive tibial transplant was doweled to fit in the medullary cavity at either end. In August, 1946, the transplant was fractured in its mid-portion. Examination in January, 1947, revealed definite evidence of callus formation, while solid bone union at the fracture site was lacking, the proximal and distal ends of the transplant were firmly united to the shaft.

Case VII—R R, male, age 38, was admitted on March 3, 1946, with a history of a swelling of the right forearm, which was first noticed in 1935, and steadily increased in size without any treatment. On March 6, 1946, the large, soft, part tumor was dissected free and removed with a $3\frac{1}{2}$ -inch segment of the ulna which was involved. A tibial trans-



FIG 3A —Case 8 Chondromyxosarcoma of inferior angle and axillary border of scapula



FIG 3B —Recurrence after partial resection of scapula

plant, dowelled at either end, was used to fill the defect. Pathologic diagnosis was very low grade spindle cell non-metastasizing fibrosarcoma. On April 15, 1947, only ten months later, the condition of the graft was satisfactory and there was no evidence of recurrence.

Case VIII—A S, female, age 32 years, was admitted in December, 1934, for a tumor of the right scapula on which a biopsy had been performed in Philadelphia, two years previously. Microscopic report: Chondromyxosarcoma, recurrent. At that time an operation—excision of part of the scapula—was performed, followed by radiation therapy. Our operation consisted of sub-total excision leaving the glenoid and neck of the scapula. A recurrence took place within six months necessitating a total excision of the scapula on August 27, 1935. The pathologic diagnosis on both of these specimens was that of chondromyxosarcoma. Examination in May, 1942, revealed the patient in excellent condition, she had a good functional result with the exception of limited abduction of the arm (Fig 3).

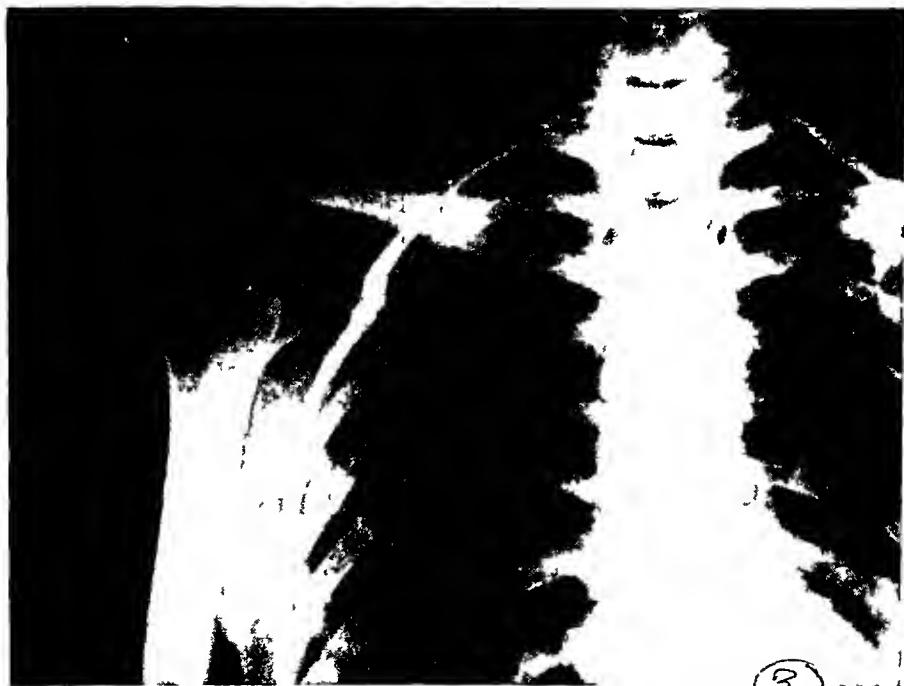


FIG 3C—After total resection of scapula. Well 12 years later.

Case IX—T V D, a 28-year-old Albino negro was admitted on April 6, 1934, with an enormous tumor of the left scapular region of two years' duration. There was a history of antecedent injury. Examination revealed a mass measuring 23 x 21 cm over the left scapula, it was elevated 15 cm, beyond the normal body surface. A total scapulectomy was performed on April 21, 1934. Pathologic diagnosis: Spindle cell osteosarcoma. Death from pulmonary metastasis took place in early April, 1936, at this time there was also evidence of a small local recurrence in the operated area.

Case X—J C V, male, age 9 years, was admitted on June 24, 1939, with a swelling of the scapula of 13 months' duration. Examination revealed a large tumor measuring

20 x 10 x 10 cm A total scapulectomy was performed on June 28, 1939 Pathologic diagnosis Angioendothelioma Postoperative treatment by irradiation and Coley's toxins was carried out The patient died on May 14, 1941, with intracranial metastasis, multiple subcutaneous nodules and pulmonary lesions, without evidence of local or regional recurrence

Case XI—H A, female, age 47, was admitted on May 10, 1940, complaining of pain and swelling in the left knee over a period of two years, during which time she had sustained four falls on the knee, the latest one a month prior to admission A cast had been applied Examination revealed the affected patella to be three times the size of the normal one but it was freely movable and there was no skin attachment Roentgenograms disclosed an osteolytic lesion involving the entire patella with accompanying soft tissue swelling An aspiration biopsy was done and the pathologist reported "Malignant tumor with a suggestion of malignant giant cell tumor" A total removal of the patella was performed on May 14, 1940, following which the pathologist reported Malignant giant cell tumor A course of Coley's toxins was given and the patient was discharged on June 21, 1940 She remained symptom-free, able to carry on her work as a machine operator, until May, 1943, when films revealed pulmonary metastasis, and she died on November 1, 1943, without evidence of local recurrence



FIG 4—Case 13 Medullary and spindle cell osteogenic sarcoma, recurrent 10 months after resection of lower end of right fibula Treated by radiation, Coley's toxins, then amputation at the site of election below the knee (instead of at or above the knee) Well 9 years later

Case XII—W R, male, age 23, was admitted on November 22, 1935, complaining of a sore knee of six weeks' duration On the direction of Doctor Ewing, he received a course of radiation therapy from November, 1935, to March, 1936 It was assumed that he had a giant cell tumor No improvement followed, in fact he continued to grow worse and in August, 1936, a high thigh amputation was performed Pathologic diagnosis Osteogenic chondrosarcoma Fourteen months later there was a recurrence in the soft tissues of the stump necessitating a hip-joint disarticulation on October 6, 1937 April 17, 1946, examination shows the patient to be in excellent condition, nine and one-half years after the second operation

Case XIII—M B W, female, age 26, was admitted on January 3, 1936, complaining of pain about the right ankle of 15 months' duration She had been operated on elsewhere in March, 1935 (resection of lower end of right fibula), and a diagnosis of osteogenic sarcoma had been made On admission she was given 40,000 millicuries of radium (element pack) and a course of Coley's toxins On January 22, 1936, an amputation at the site of election below the knee was performed Pathologic diagnosis Medullary and periosteal spindle cell osteosarcoma Examination in July, 1946, more than ten years later, revealed the patient in excellent condition, she has been able to earn her living as a clerk during this period (Fig 4)

Case XIV—W C, male, age 30, was admitted on February 10, 1937, with a history of having injured the fifth finger of the right hand in November, 1936, when it was struck by a casting. There had been two operations for removal of tissue for diagnostic purposes. The first sections revealed chronic osteitis and the second were suggestive of giant cell tumor. However, the roentgenograms pointed more definitely to a diagnosis of osteogenic sarcoma. Operation performed on February 16, 1937, at Memorial Hospital consisted of partial amputation of the hand involving removal of the fourth and fifth fingers. The pathologic diagnosis of osteogenic sarcoma, low-grade, made by Doctor Stewart was confirmed by a number of the Committee of the Bone Sarcoma Registry. *Examination* on March 20, 1946, showed the patient to be in excellent condition with a useful hand more than nine years after the operation.

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THE CLOSURE OF COLOSTOMIES*

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AS IN THE FIRST years following World War I, there has been a revival of interest in technics of colostomy closure. The magnitude of the recent conflict, and the greatly increased appreciation of the value of colostomy in the primary operative management of gunshot wounds of the colon, have afforded incomparable opportunities for evaluation of existing methods of making and closing colostomies.

Poor results attributable to the technic employed in closing a colostomy can be roughly grouped under three categories:

- (1) Reopening of the closure with persistent fecal drainage
- (2) The occurrence of hernia at the site of closure
- (3) Pain at the site of closure, associated with varying degrees of obstruction to the fecal stream

In the closure of any opening in the colon, whether traumatic or elective, certain fundamental surgical principles obtain. These are usually followed without question in cases of elective anastomosis of the bowel, but are often neglected in technics of colostomy closure:

- (1) The blood supply to the bowel edges to be sutured must be preserved
- (2) Free edges of bowel must be accurately and snugly coapted without tension
- (3) Approximation of visceral peritoneal surfaces must be obtained if possible
- (4) The creation of obstruction or stenosis at the site of closure, either secondary to the technic of closure itself, or due to faulty repositioning of the sutured bowel, must be avoided

If these principles are maintained, the closure of the opening in the bowel should remain secure. If they are neglected, no amount of chemotherapy or of reinforcement with fascial or other extraperitoneal layers will prevent leakage, infection, and reopening of the closure.

The avoidance of wound infection in an unavoidably contaminated field by refraining from extensive dissection of the various layers of the abdominal wall during the closure is also important. Such dissection tends to open up

* Presented at the meeting of the Central Committee on Fractures and other Traumas of the American College of Surgeons, January 15, 1946 Chicago, Illinois

virgin tissue planes and spaces which have less resistance to infection than those adjacent to the colostomy. The reopening of an infected wound is most often followed, in short order, by reopening of the exposed suture line in the bowel itself. Preoperative preparation of the bowel with sulfasuxidine (sucinylsulfathiazole or sulfaphthalidine (phthalylsulfathiazole) is undoubtedly of great value, but from our experience is not of supreme importance.

Intraperitoneal methods of closure greatly facilitate the proper observation of these surgical principles and particularly eliminate the danger of compressional or positional kinking of the sutured bowel, which is inherent in any extraperitoneal method of closure. Obstruction at the closure site by what



FIG 1—Lumbar colostomy made by exteriorizing damaged portion of upper cecum and first portion of ascending colon through wound of entrance of missile. Closure of this colostomy was very difficult and necessitated widespread mobilization and extensive dissection to provide a firm closure of the colon and a good repair of the lumbar tissues.

Warwick has termed "intraluminal kinking" remains a hazard in any type of closure, but can be reduced to a minimum by meticulous suturing or can be compensated for by a special type of anastomosis which will be described later.

MATERIAL

Seventy-two consecutive colostomy closures, done during a 15-month period, form the basis of the present study. The colostomies were all originally performed as adjuncts to the primary surgical management of gunshot wounds of the large bowel, ranging from the cecum to the terminal two inches of rectum. The types of colostomy encountered ran the gamut from orthodox to bizarre, as regards construction and site. Examples of lumbodorsal, flank, and low thoracic colostomies were included, as well as the more usual exteriorizations of riddled colonic segments, rotated colostomies, and partially retracted colostomies, (Fig 1, 2). In one case, a transverse colostomy had been brought

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out of the abdomen through a small stab wound low down in the left lower quadrant, (Fig 3), and in another a sigmoid colostomy had been brought out through the internal inguinal ring and upper part of the left inguinal canal

PREOPERATIVE CARE

Adequate information about the structural details of the colostomy were lacking in most of these cases. In no instance did we enjoy the privilege of closing a colostomy that we had made ourselves. Since all the colostomies in this series had been performed for penetrating wounds of the abdomen, involving not only the colon but other abdominal viscera and organs, the decision to



FIG 2—Flank exteriorization of damaged portion of descending colon just below splenic flexure. Proximal and distal stomas are indicated by pointers and have retracted about 1" below skin surface. The herniated mucosal mass of the riddled colonic segment contains four accessory openings. Colostomy has been brought out through wound of entrance of missile.

close a colostomy depended on the status of associated lesions in the small bowel, urinary tract, bony pelvis and distal colon. In many cases, extensive surgery was necessary for the cure or elimination of such lesions, usually before, but often at the time of closure of the colostomy. In some instances a poorly placed colostomy was closed and replaced with one more suitably located, which remained to be closed after further reconstructive surgery had been done upon the distal bowel. Such reconstructive surgery included transperitoneal closure of ureterosigmoid, vesico-rectal and hepatico-colic fistulae,

as well as the more usual and simpler closures of sacral, perineal and flank fecal fistulae (Fig 4) In a number of cases, resection of extensive segments of colon, including the colostomy, was done (Fig 5)

With a view to anticipating and reducing complications that might arise at, or after operation, an extensive program of preoperative study, preparation and evaluation was undertaken for each case (Table I)

OPERATIVE TECHNIC

The methods of closure employed ranged from simple extraperitoneal closure, to resection of the colostomy and adjacent four to eight inches of bowel, with end-to-end anastomosis Only 12 extraperitoneal closures were

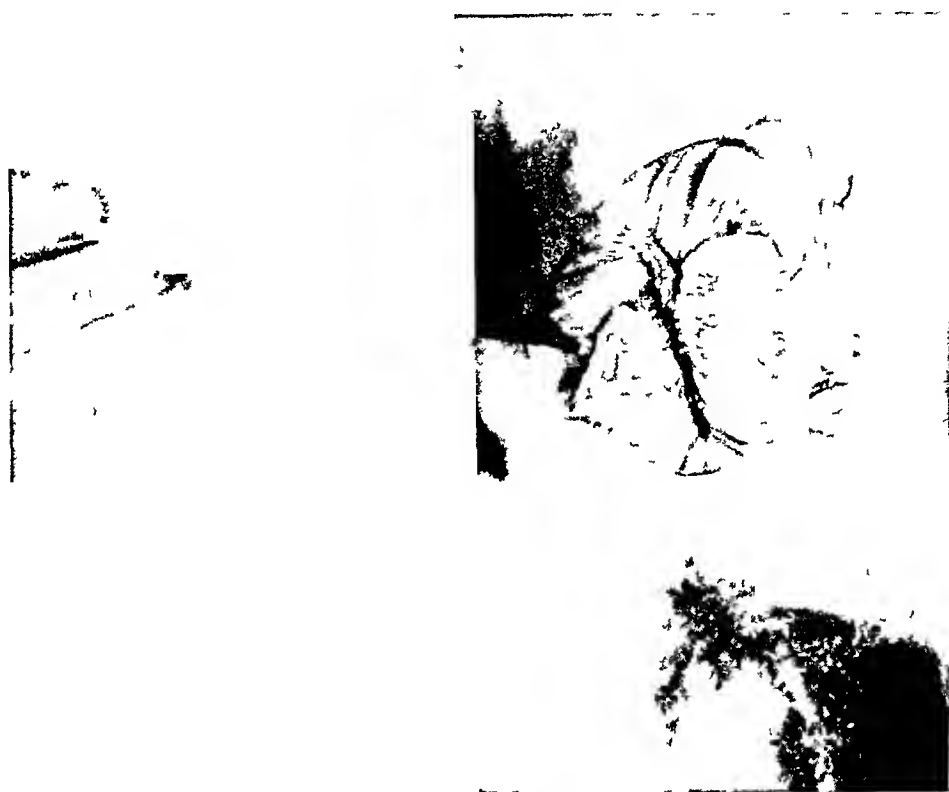


FIG 3—Transverse colostomy brought out through small oblique incision in left lower quadrant. Note massive edema, mucosal prolapse and rotation of colostomy (approximately 95°). Pointer is in proximal stoma.

done, and this method was abandoned early in the series. In 24 consecutive cases an intraperitoneal closure utilizing a modification of Pauchet's technic of anastomosis was employed with very satisfactory results. With the exception of the Pauchet closures and four cases of resection and end-to-end anastomosis, the remainder, or 32 cases, were closed by an intraperitoneal technic similar to that described by Dixon and Benson (Fig 6). The surgical principles previously outlined were scrupulously followed in all closures but two, both done by the extraperitoneal route. These two closures reopened for a short time, but later closed spontaneously without the necessity for further surgical intervention.

TABLE I—*Routine Preoperative Colostomy Study**

-
- I In addition to the usual laboratory work the following should be done
- (1) Prothrombin time,
 - (2) Vitamin C—blood level
 - (3) Plasma chlorides,
 - (4) Plasma-proteins
 - (5) NPN.
 - (6) Weigh the patient
- II In addition to the ordinary physical examination, the following should be done
- (1) Digital rectal examination
 - (2) Digital colostomy examination (under pentothal anesthesia if necessary)
 - (3) Examine for skin excoriation around colostomy (If present, Kaolin paste should be applied twice daily)
 - (4) Tap water enema, 500 cc through distal loop If any debris exists in distal loop, enema should be given daily until cleared
 - (5) Procto-sigmoidoscopy *Precaution* In injuries to the pelvic colon especially following buttock or perineal wounds, the bowel is often fixed by scar and inflammatory tissue making the passage of the sigmoidoscope difficult or impossible and *always hazardous* *Extreme gentleness* must be observed for the avoidance of both pain and serious trauma to the colon
- III
- (1) Educate patient, if not already trained, to care for his own colostomy
 - (2) Daily bath
 - (3) 2000 cc tap water enema through proximal loop at approximately same time every third day until preoperative sulfasuxidine is started
 - (4) Kaolin paste around stoma if *any* excoriation is present
 - (5) High caloric—low residue diet
 - (6) Supplementary vitamin therapy
- IV Special studies
- (1) Open film of abdomen for retained foreign bodies in *all* cases
 - (2) Intravenous pyelogram *In every case*
 - (3) Barium enema (Don't give barium to a patient going on furlough unless 2-3 days are spent thereafter *in the hospital* thoroughly evacuating barium from distal loop Because of the peculiar physiological status of an inactive distal loop barium may be incompletely evacuated and develop into a considerable plug)
 - (4) Weigh patient once a week
 - (5) Cystoscopy, retrograde pyelography, GI series, cholecystography, etc., will be done according to indications in each case
- PRECAUTIONS
- (1) *Don't* send any patient on furlough with barium still in the distal loop
 - (2) *Don't* send any patient on furlough with an *internal* fistula, without a *thorough* workup including consultations, (for example urologic consultation in the case of urinary-fecal communications)
 - (3) Be sure each furlough patient understands the care of his colostomy including diet, cleanliness, enemas, etc
 - (4) *Don't* send any patient on furlough who has skin excoriation around colostomy.
- V Chemotherapy
- (1) Sulfasuxidine 025 Gm per kg daily in four divided doses and Synkayvit (synthetic vitamin K) 5 mg TID by mouth for at least six days All enemas, and colonic irrigations should be withheld during sulfasuxidine administration
 - (2) Prothrombin time before starting sulfasuxidine and on day prior to operation
 - (3) If skin excoriation develops around the colostomy during sulfasuxidine preparation, notify surgeon promptly, instruct patient to bathe several times daily and apply kaolin paste more frequently
 - (4) Tap water enema (1 000 cc) to both loops on night before operation
 - (5) Paregoric 8 cc night before operation and repeat in A M before operation
- VI *Postoperative Routine*
- (1) Full liquid diet as tolerated upon return from operating room
 - (2) Mineral oil 15 cc Q I D
 - (3) Rectal tube, q 2 hrs
 - (4) Patient may be ambulatory on the first postoperative day
 - (5) Soft diet, first or second postoperative day as tolerated
 - (6) Regular diet as soon as spontaneous bowel movements appear
- Note—Sulfasuxidine is not to be continued postoperatively except in special cases involving extensive bowel resection or upon the individual recommendation of the surgeon
-

* The outline as given above was published on each surgical ward for the guidance of the ward personnel Apologies are tendered for the obvious naiveté of the instructions

All operations were done under spinal anesthesia. A simple preparation of the operative field with soap, water, ether, and a suitably tinted skin antiseptic was found to be completely adequate. Irrigation of the colostomy on the operating table, the use of gauze plugs, and other complicated procedures described elsewhere, were not employed.

The operative incision was closed without drainage in all but five cases. In three of these the technic of delayed closure, described by Collier and Valk, and by Pemberton, was employed. In one case, a Penrose tube was left for



FIG 4—Lipiodol injection made solely through sacral opening of uretero-sigmoid fistula, showing sigmoid and ureteral connections. The left hydronephrosis subsided with the passage of four calculi, following dilatation and catheter drainage of the left ureter and kidney pelvis. Cure of the fistula obtained by establishment of Devine colostomy in transverse colon, closure of sigmoid colostomy, and finally, transperitoneal closure of fistulous openings in recto-sigmoid and left ureter. The left kidney was preserved.

36 hours down to the site of closure of an associated hepatico-colic fistula. In another case, in which the wound of entry had been used to bring out the colostomy from the abdomen, an inevitable subcutaneous dead space resulted, which was drained for 36 hours by a Penrose tube.

CHEMOTHERAPY

In a majority of cases preoperative preparation of the colon for six days with sulfasuxidine (succinylsulfathiazole) and a low residue diet was carried

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out At first, sulfasuxidine was given on a basis of 25 Gm per kg of body weight per day in four divided doses, as recommended by Poth and Knotts. Later, four daily doses of two or three grams each, depending on the approximate weight and size of the patient, were routinely employed. Enemata and colon irrigations were withheld during sulfasuxidine administration. In only three cases involving fairly extensive bowel resection was sulfasuxidine continued postoperatively. After the appearance of hemorrhagic phenomena in

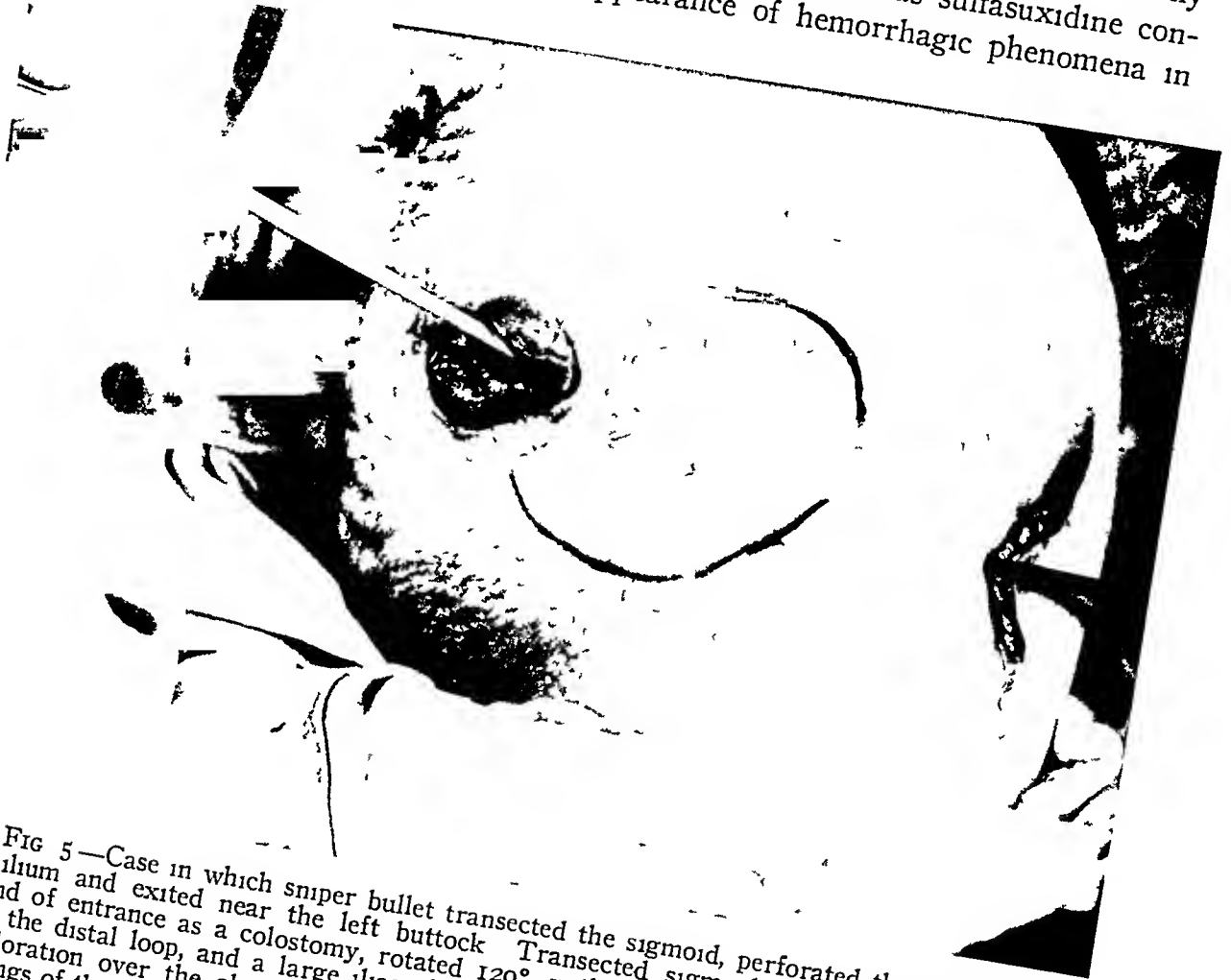


FIG 5—Case in which sniper bullet transected the sigmoid, perforated the ala of the left ilium and exited near the left buttock. Transected sigmoid brought out through wound of entrance as a colostomy, rotated 120°, with the development of a fecal fistula from the distal loop, and a large iliac abscess, which is outlined on the skin. The skin discoloration over the abscess can be seen. Pointers are in the internal and external openings of the fecal fistula which traverses the ala of the left ilium. Cure involved establishment of Devine colostomy in transverse colon and drainage of the abscess, later, resection of involved sigmoid and end-to-end anastomosis.

two instances, synthetic vitamin K was given by mouth during sulfasuxidine administration to all subsequent patients. The topical application of crystalline sulfanilamide to the suture line in the bowel and to the layers of the operative wound was carried out in a few cases, and then discarded as unnecessary. In four cases no sulfonamide therapy whatsoever was employed.

POSTOPERATIVE CARE

All patients were given a liquid diet upon returning from the operating room, and most had progressed to taking a regular house diet by the third or

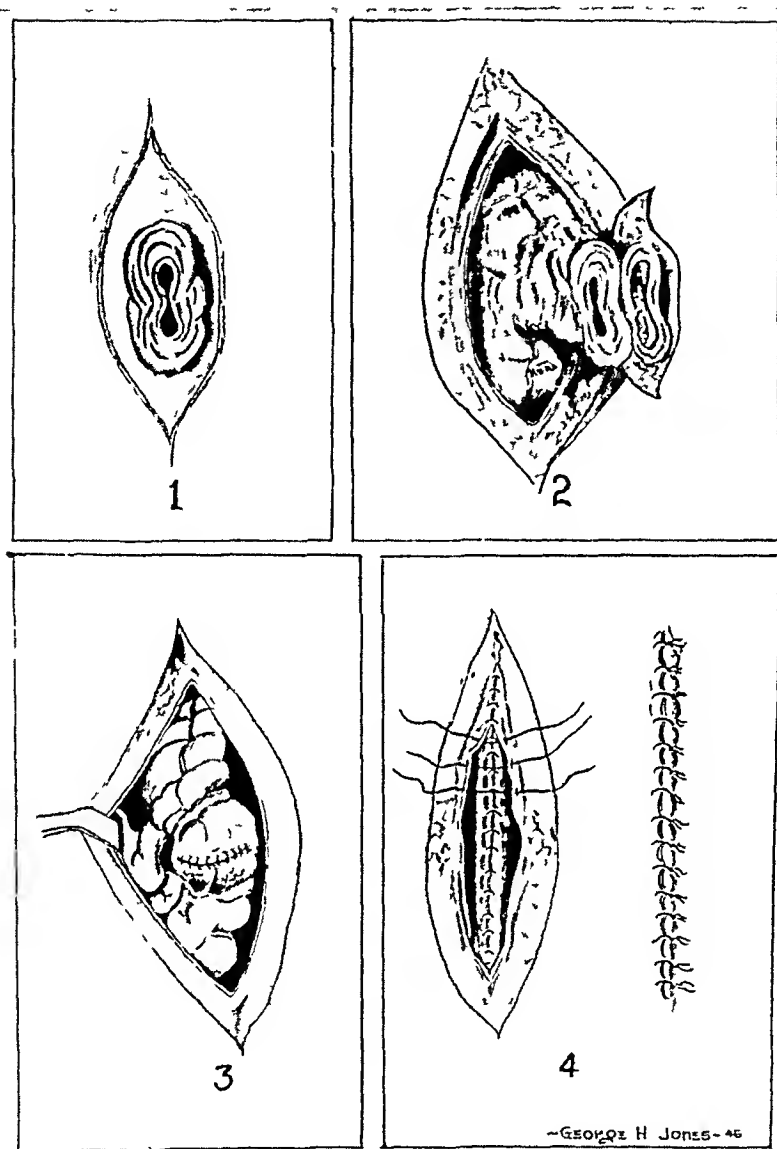


FIG 6—Technic of Simple Intra-Peritoneal Colostomy Closure
(After Dixon and Benson)

(1) Elliptical incision encircling stoma (Spur has been previously crushed)

(2) Incision carried down through all abdominal layers, opening peritoneal cavity Mucocutaneous cuff of stoma resected

(3) Transverse closure of colostomy, using two layers of sutures

(4) Wound closed in layers without drainage, using interrupted sutures of fine cotton or silk Topical sulfonamide is not employed

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fourth postoperative days Parenteral fluids, blood and plasma transfusions, were rarely necessary postoperatively Periodic insertion of a rectal tube was begun as soon as the patient returned from the operating room in order to

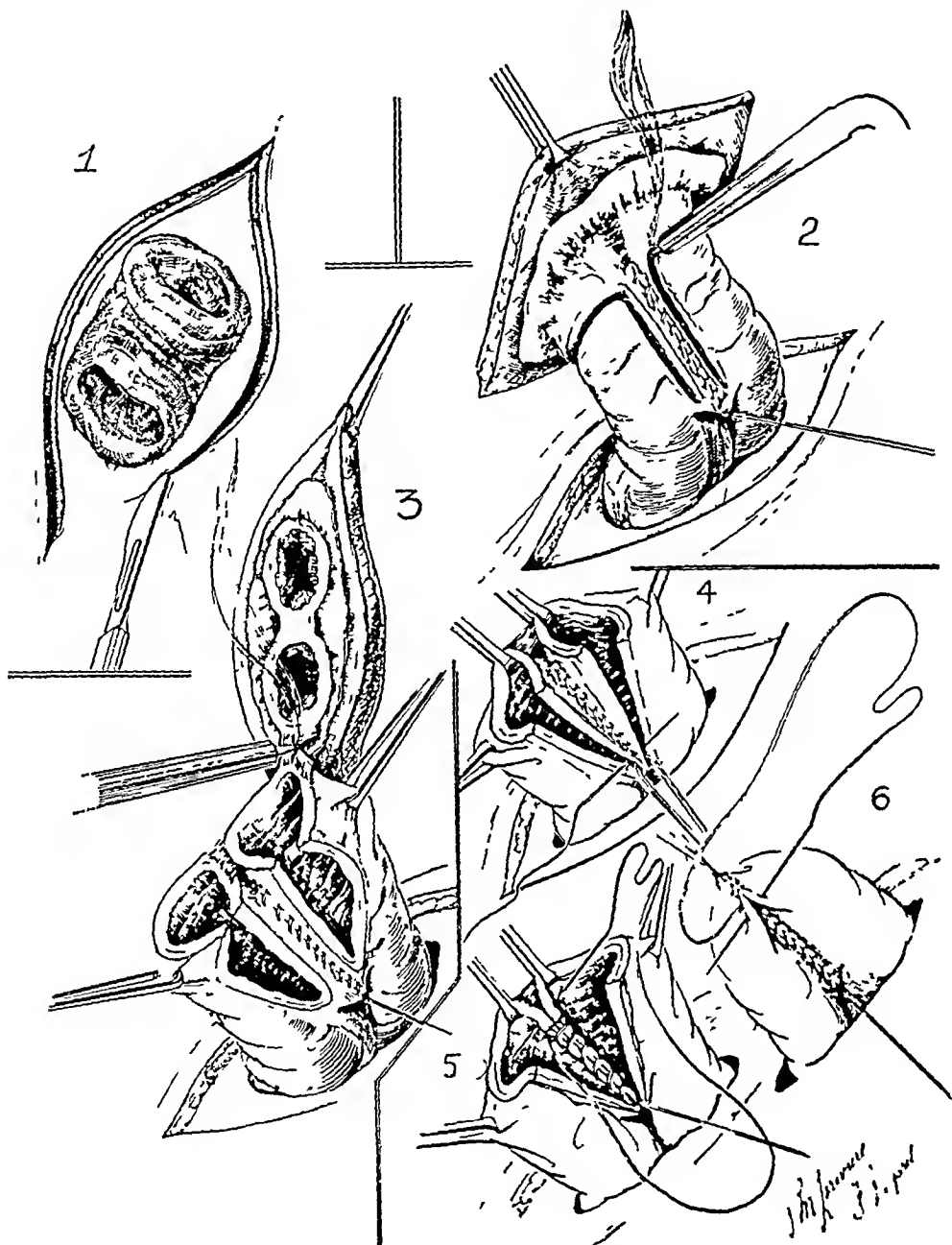


FIG 7—Pauchet Technic of colostomy closure The cautery is not used in our modification of this procedure The colostomy stoma and adherent skin cuff are excised with the scissors The vertical incision in the long axis of each bowel limb is made, also with scissors, from the stoma downward, instead of as shown The continuous suture shown in 5 is usually continued down the lateral aspect of the anastomosis as a continuous Connell stitch in our technic Interrupted Halsted sutures of fine black silk are substituted for the continuous Lembert suture shown in 6 (Reproduced by permission of the publisher from Maingot, ABDOMINAL OPERATIONS, Vol II, Page 1334, D Appleton-Century Co, New York)

decompress the colon distal to the closure This was continued until the first bowel movement, which was usually on the third or fourth postoperative day All patients were ambulatory by the fifth or sixth postoperative day

PAUCHET CLOSURE

In 24 cases a modification of Pauchet's technic of intraperitoneal colostomy closure was done

This procedure embodies largely the principle of the Finney pyloroplasty, and briefly consists in encircling the colostomy stoma by an elliptical skin incision, leaving a cuff of skin about one-quarter inch around the mucosal edge. The incision is deepened in an anatomic manner by sharp dissection through all the layers of the abdominal wall down to the peritoneum, which is then deliberately opened along the medial aspect of the colostomy. The peritoneal incision is continued by sharp dissection so that it completely encircles and frees the afferent and efferent limbs of the colostomy. With gentle traction on the bowel, further mobilization is continued as far as is necessary to provide an adequate length of bowel for the anastomosis, and to permit, if necessary, resection of the colostomy or of segments of bowel deformed by secondary fistulas, extensive scarring or granulomatous masses. Proper mobilization permits complete delivery from the abdominal cavity of the afferent and efferent limbs of bowel to be used in the anastomosis. The wound edges and the peritoneal cavity are protected by two large saline packs tucked snugly down into the wound around the bowel. All subsequent surgical procedures are then carried on entirely outside the abdominal cavity and the operative wound. The anastomosis is performed (Fig 7) after such complications as bowel rotations and interposition of small bowel or omentum, *etc*, are corrected and after resection of undesirable segments of bowel has been completed. Upon completion of the anastomosis, the bowel is carefully replaced within the peritoneal cavity so as to avoid twisting or kinking, and the wound is then closed in layers without drainage.

At first we employed the method for the closure of colostomies whose defects or complications prohibited spur crushing and simple intraperitoneal closure. The good results and smooth postoperative course in these first few cases, and the obvious advantage to our patients of avoiding the time lost in a spur crushing procedure, impelled us to adopt the method as the procedure of choice in closing subsequent colostomies. The advantages of the method are, in general, those of any intraperitoneal type of closure in avoiding positional and compressional kinking of the bowel at the site of the closure, in providing for an adequate repair of the abdominal wall in which the development of hernia subsequently is extremely unlikely, and in the general security of the closure itself. In addition to these advantages, the method insures a very generous lumen at the site of anastomosis, even though a firm, leakproof, three-layer anastomosis is done, turning in a generous cuff of bowel wall. By this method, the development of obstruction at the site of closure from either extrinsic or intrinsic causes, is completely avoided or compensated for to a degree not attainable with end-to-end anastomosis, and the other prime requisites for a successful closure already mentioned are ensured.

The postoperative course of these 24 patients was very smooth. A full liquid diet was taken by all patients in this group upon their return from the

CLOSURE OF COLOSTOMIES

operating room. All patients were ambulatory by the first postoperative day. Flatus was passed freely per rectum on the first or second postoperative day, normal bowel movements occurred on the second or third day, usually without enemata or catharsis, and all patients were taking a regular house diet by the third day. Gas pains, distention, vomiting, the withholding of food, the use of suction decompression, parenteral fluids, and other postoperative nuisances, were conspicuously absent. There were no wound infections, wound reactions, or failures of the closure, in this group. Barium studies of the colon at three



FIG 8—Barium Study of Colon four weeks after Paquet closure of Colostomy

to four weeks postoperatively revealed adequate, or even generous lumens in each case, without evidence of postoperative stricture or stenosing deformity (Fig 8)

RESULTS

The results in 72 consecutive colostomy closures are shown in Table II

COMMENT

There were no deaths. Failure of the closure occurred in two cases, early in the series, due to faulty technic. In these two cases, we presume that some degree of wound infection took place. This, however, was completely masked

or overshadowed by the reopening of the closures, on the fourth and fifth days, respectively, which was of a somewhat cataclysmic nature

There were no wound infections or "reactions" in the remaining 70 cases. All incisions appeared to be healing well without reaction on the sixth postoperative day, at which time skin sutures were removed. Subsequent healing was uneventful and resembled that expected in clean elective incisions.

Following the appearance of hemorrhagic phenomena in two patients on the second postoperative day, due to hypoprothrombinemia, synthetic Vitamin K was given by mouth during sulfasuxidine administration to all subsequent patients. Routine studies of prothrombin time, done the day before sulfasuxidine preparation was begun, showed high normal values in these two patients.

TABLE II—*Results in 72 Consecutive Closures of Colostomies Done for Battle Wounds of the Colon*

	Number	Per Cent
Failure of closure	2 (Closed spontaneously later)	2.8%
Wound infection	2 (?)	2.8%
Healed by 14th postoperative day	70	92.2%
Persistent sinus with drainage	0	
Pain at site of closure	0	
Hernia at site of closure	0	
Stenosis at site of closure	1 (following end-to-end suture)	1.4%
Obstructive symptoms at site of closure	0	

With the appearance of hemorrhagic phenomena postoperatively, namely, rectal bleeding, the prothrombin time was again determined in these two patients and found to be less than 10 per cent of normal. In both cases, bleeding stopped within three hours following the intravenous administration of large doses of Vitamin K and the restoration of normal prothrombin values. Although acceptable proof is lacking, we feel that the marked reduction in vitamin K-synthesizing colonic bacteria brought about by sulfasuxidine, was at least partly responsible, and suggests interesting possibilities for clinical investigation.

It is difficult for us to evaluate the clinical results of sulfasuxidine preparation of the bowel from our experience with such a small series of cases. At least a dozen closures were performed without sulfasuxidine preparation, and it appeared to us that their postoperative course was fully as smooth as regards wound healing, absence of febrile reaction, minimal postoperative discomfort, gas pains, *etc.*, as those in which sulfasuxidine was given preoperatively. At the operating table, however, the advantages of sulfasuxidine preparation were more clearly demonstrated by the scrupulous cleanliness and complete absence of fecal debris in the colon thus prepared. From these observations we have concluded that sulfasuxidine preparation is of great value in reconstructive surgery of the large bowel, including colostomy closures, but is certainly not indispensable.

SUMMARY

Experience with 72 consecutive colostomy closures has resulted in a decided preference for a method of colostomy closure which will provide the following

1 As nearly anatomic a reconstruction of the colon and abdominal wall as is possible, namely, an intraperitoneal type of closure

2 A technic of closure which obviates the wastage of time and the not too remote dangers attending a preliminary spur crushing procedure

3 A type of intestinal anastomosis which will allow the surgeon considerable freedom in suturing so that he may make a two, or even three, layer closure of great firmness, turning in a sufficient cuff of bowel wall to ensure excellent peritoneal coaptation, and yet at the same time leaving a sufficiently large lumen at the site of closure which will not under any circumstances become stenotic, either due to immediate postoperative edema, or later from cicatricial contraction

In the main, end-to-end anastomosis, with or without actual resection of the colostomy itself, satisfies these requirements fairly well. Nevertheless, it has been our experience in a significant number of cases, that, with this method, immediate postoperative edema has sufficiently compromised an otherwise adequate lumen, so as to endanger the integrity of the suture line or to cause postoperative discomfort, cramps and other nuisances. Consequently, our decided preference is for the Pauchet type of closure, which we have come to employ almost exclusively for the closure of colostomies in the transverse, descending, and sigmoid colons. In our experience with this type of closure, withholding of food postoperatively is unnecessary, postoperative discomfort is minimal, early ambulation is accomplished readily, wound infection, leakage or failure of the closure, and obstructive symptoms, either early or late, are thus far unknown.

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MODERN CONCEPTS OF URETERAL CALCULI

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IT IS NOW generally conceded that ureteral calculi are originally formed in the kidney and then pass into the ureter. Calculi which develop *ab initio* in the ureter are rare, as the smooth mucosal lining is constantly being washed with urine, and because gravity exerts a pulling force on crystalloid accumulations of stones. However, cases have been reported in which anatomic or pathologic areas of stasis (sacculations or diverticula) are undoubtedly responsible for the formation of ureteral calculi.

Available reports cite instances in which ureteral stones have formed in connection with ureteroceles, neoplasms, ureters with blind endings, or ectopic ureters. This series of 256 cases is reviewed not only to ascertain general information governing ureteral calculi, but also to compare the type of treatment instituted with that of previously reported series. This presentation is a supplementary report on ureteral calculi treated at Cleveland Clinic from 1939 to 1945.

Etiology—Inasmuch, as ureteral calculi are usually formed in the kidney, the factors governing the formation of renal calculi merit consideration. It is generally accepted that no single etiologic factor is responsible for the formation of the calculi. Thus, if the causative factors in the individual case are not determined and eradicated, recurrent stone formations will ensue. It is evident that only by intensive preoperative investigation and diligent postoperative management can the morbidity of this disease be reduced.

In view of our present knowledge of calculus formation, the following factors must be studied: (1) hyperparathyroidism; (2) vitamin-A deficiency; (3) stasis, (4) metabolic diseases, (5) focal infection, and (6) infections of the urinary tract.

Each etiologic factor warrants investigation in order that, if present, it may be corrected at the time of operation or during the period of postoperative observation.

Age Incidence—Stone in the ureter is essentially a disease of middle life. In this series, 69 per cent occurred between the ages of 21 and 50 (Table I).

TABLE I
AGE INCIDENCE

Age	Cases
1-10 years	0
11-20 years	2
21-30 years	31
31-40 years	55
41-50 years	91
51-60 years	58
61-70 years	18
Over 70 years	1

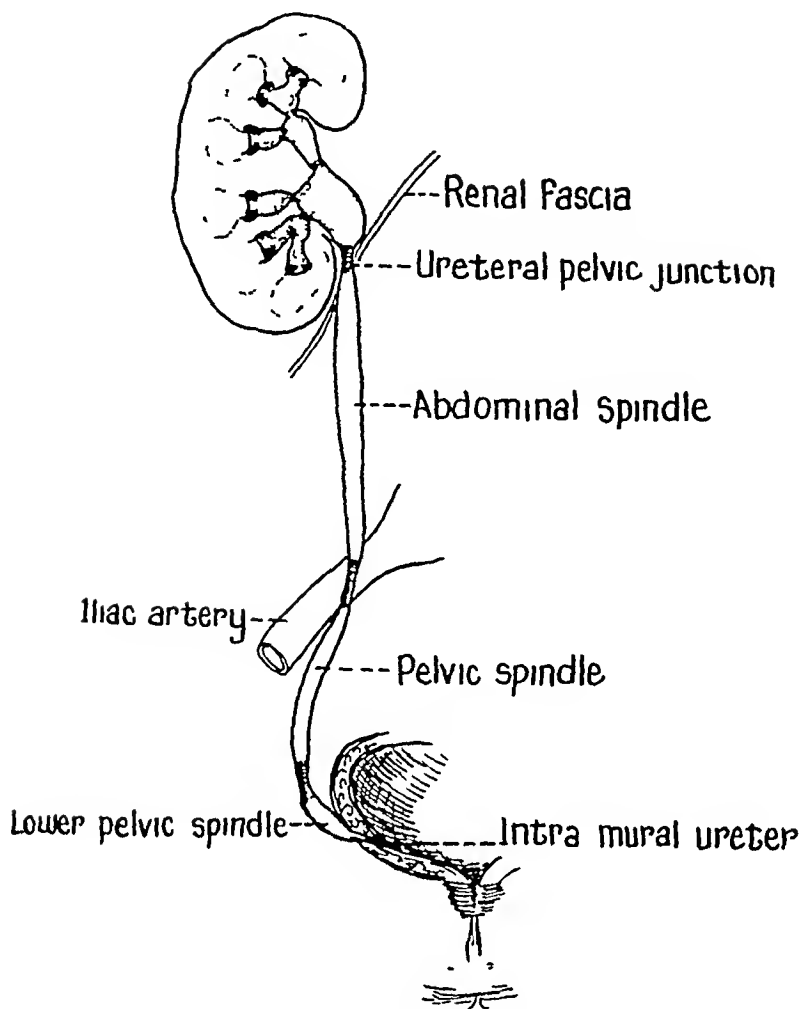


FIG 1—Points of constriction in the normal ureter

The youngest male was 20 and the youngest female 22 years of age. The oldest male was 72 and the oldest female 61 years of age. These results agree with a series of 122 cases reported by Mathe (Table II).¹

TABLE II
AGE INCIDENCE OF MATHE'S CASES

Age	Cases
0-10 years	0
10-20 years	6
20-30 years	13
30-40 years	28
40-50 years	34
50-60 years	24
60-70 years	17

Sex—The incidence of ureteral calculus is much greater in men than in women. Ravich² states that 69.8 per cent occur in men and 30 per cent in women. Bumpus and Scholl³ observed 68 per cent in men and 32 per cent in

women In a series of 350 cases reported by the author in 1939, 79.7 per cent were in men and 20.3 per cent in women.⁴ In this series of 256 cases, 79 per cent were in men and 21 per cent in women.

Side Involved—The occurrence of ureteral calculi on the left and right sides is approximately equal. Kietschmer⁵ observed that in 500 cases, 45.8 per cent were on the right side and 54.2 per cent on the left side. In our series of 350 cases previously reported, 46 per cent were in the right ureter and 54 in the left ureter. In this series of 256 cases, 47 per cent were in the right and 53 per cent in the left ureter. Bilateral ureteral calculi occur in 1.7 to 3.6 per cent of cases.

Location of Calculus—The majority of calculi become impacted in the pelvic portion of the ureter. As a general rule the descent of the stone is arrested at one of five points in the ureter. These points are the normal locations of constriction to be found in the ureter (Fig. 1), namely, (1) at or just below the ureteropelvic junction, (2) at the point where the ureter crosses the iliac vessels, (3) at the base of the broad ligaments in the female and of the vas deferens in the male, (4) at the point where the ureter enters the external muscular layer of the bladder, and (5) at the ureteral orifices. In our series of 350 cases the location was as shown in Table III.

TABLE III
LOCATION OF CALCULI

Right upper ureter	14 cases
Left upper ureter	16 cases
Right midureter	21 cases
Left midureter	22 cases
Right lower ureter	128 cases
Left lower ureter	143 cases
Bilateral calculi in 6 cases	
Right and left lower ureter	3 cases
Right lower ureter and left upper ureter	1 case
Right midureter and left midureter	1 case
Right midureter and left lower ureter	1 case
In this series of cases the following location was noted	
Right upper ureter	15 cases
Left upper ureter	22 cases
Right midureter	7 cases
Left midureter	12 cases
Right lower ureter	89 cases
Left lower ureter	99 cases

The location of the calculus was not stated in 12 instances.

SYMPTOMATOLOGY

The symptoms produced by a stone in the ureter may so closely simulate those produced by a stone in the kidney that roentgenologic study may be necessary to establish the correct diagnosis. The position of the calculus, the presence or absence of obstruction or infection, and the movement of the stone may influence the symptoms.

Pain was the predominant symptom in this series. It occurred as colic in 151 (59 per cent) of cases, and as unilateral costovertebral-angle pain in 51 (20 per cent) of cases. Indefinite abdominal discomfort was present in 57 (22.7 per cent) of cases, and nausea and vomiting in 94 (36 per cent).

In the 350 cases previously reported, 20 per cent presented symptoms not referable to the urinary tract in contrast to 22.7 per cent above. In the previous series, in 14 per cent of the cases the pain was referred to the upper quadrants of the abdomen, and in 6 per cent the pain was referred to the right or left lower quadrants.

Bumpus and Thompson⁶ found that the appendix had been removed in 26.8 per cent of the 138 cases of ureteral calculi prior to establishing an accurate diagnosis.

Calculi in the upper ureter produces pain either as colic radiating around the abdomen to the genitalia or by obstruction producing a fixed sharp or dull pain in the posterior renal area. Stones in the pelvic portion of the ureter may produce colic, obstructive symptoms, and also pronounced vesical symptoms. In one patient the only complaint was severe pain in the testicle, others had pain referred to the perineum, rectum, medial portion of the thigh, and localized pain medial to the knee joint.

During their attacks nearly half of the patients noted frequency. Urgency was present in 31.3 per cent of the 256 cases, and many of the patients gave a history of vague abdominal pains associated with frequency. This led to complete urologic examination and finding of a calculus.

Urine examination revealed microscopic hematuria in 212 (82.8 per cent) and gross hematuria in only 94 cases (36.7 per cent). Microscopic pus was present in the urine in 226 (89 per cent).

Carp⁷ states that in a study of 100 patients with ureteral calculi 93 per cent developed a leukocytosis. Of this group 20 per cent had white blood cell counts of from 15,000 to 30,000, 42 per cent from 10,000 to 15,000, and 31 per cent from 7,000 to 10,000. He states that this finding is of great significance and should be incorporated in the classical picture of ureteral calculus.

Roentgenographic refinements in technic have made the number of undiagnosed ureteral calculi exceedingly small. Peterson and Holmes⁸ found in 100 cases that 96 per cent were diagnosed by roentgenologic study. The most frequently overlooked calculi were located in a small area medial to the spine of the ischium and just above a line joining the lowest part of the ischial spines.

In this series of 256 cases 98.4 per cent of the stones were demonstrated roentgenologically. Two hundred and thirty-seven were visualized on the initial roentgenogram, and 15 additional calculi were shown by the use of radiopaque dye.

Stones lying low in the ureter render cystoscopic examination a valuable adjunct in diagnosis. A calculus approaching the bladder will make typical changes of edema about the ureteral orifice, a definite bulging may be noted, a gaping orifice, or the calculus in the orifice may be observed.

Other corroborative evidence includes striking an obstruction with a ureteral catheter (plain or wax-tipped) and the hydronephrotic drip of urine. It is also suggestive after a catheter has passed a grating obstruction, followed by relief of pain in the renal area.

During the present decade intravenous urography has become an important

diagnostic aid In addition to demonstrating opaque and nonopaque stones a physiologic picture of renal function is secured, thereby giving an index of the proper therapeutic course to be followed By the employment of intravenous urography we can determine the status of the kidney above the calculus, *i e*, the degree of hydronephrosis, if present, and determine if complete or only partial obstruction is being produced by the stone It also obviates the chances of dislodging the stone and forcing it back into the renal pelvis if a catheter (ureteral) is introduced through the cystoscope

TREATMENT

Few urologic problems require consideration of so many factors as does an obstructing ureteral calculus Whether or not to operate and relieve the obstruction immediately or to manipulate and possibly subject the patient to a period of disability, painful colic, and possible febrile reactions is a question arising in every case Likewise should a period of watchful waiting be pursued What are the factors to be evaluated in deciding whether or not the patient should be carefully watched in anticipation of spontaneous expulsion of the stone, manipulation procedures should be recommended, or surgery advocated?

(1) *Economic Status and Occupation* As the economic status of the patient and his occupation may influence the procedure to be advocated for medical problems extraneous to the urinary tract, so may it influence the type of therapy to be recommended in a patient with ureteral calculus

A sudden attack of colic in persons working with machinery, airplane pilots, engineers, *etc*, may not only endanger their lives but also those dependent upon them A laborer in whom a stone impacted in the upper ureter passes slowly down the ureter, its progress at times being arrested for varying periods of time, and who is subjected to repeated attacks of colic may be restored to gainful occupation more quickly by the surgical removal of the stone through a muscle-splitting incision

There are, likewise, occupations which require considerable exertion and expenditure of energy and provoke frequent attacks of colic in the patient, who may, due to his financial status and obligations, require more immediate relief of symptoms

(2) *The Size of the Calculus* This is of considerable importance, but we are of the opinion, as are others throughout the literature, that of equal importance is the size of the ureter below the stone It is a relatively easy matter to pass catheters or extractors along the sides of a stone in a large ureter, and often impossible to pass a catheter by a small stone in an undilated ureter As a general rule, the larger the calculus the less likely it is to pass spontaneously, and more frequently will manipulative efforts fail to succeed

Joly⁹ has stated that patients passing stones at varying intervals of time are able to pass progressively larger calculi Thompson and Kibler¹⁰ state that in 361 cases of ureteral stones in which manipulative procedures were used, in 46 per cent the stones measured 1 to 2 cm, in 19 per cent the

diameter varied from 0.5 to 1 cm, and in 20 per cent the diameter was less than 0.5 cm. In our experience stones larger than 1.5 cm in diameter are rarely amenable to transurethral manipulation.

(3) *Status of Kidney above the Calculus* Final acceptance of any method of ureteral calculus therapy should have as its prime objective prevention of destruction or loss of function of the kidney on the affected side. Maintenance of urinary flow is aided by the irregular shape of most ureteral calculi. Repeatedly, we have seen linear grooves and irregular channeling in the presence of hopelessly impacted stones that have been present for years with no apparent renal damage.

However, clinical evidence of renal back pressure confirmed by intravenous urograms indicating complete ureteral obstruction or a progressively enlarging hydronephrosis signifies that conservative methods of treatment are unwarranted, and surgical intervention should be carried out.

Dourmashkin¹¹ states that the important thing to remember in cases of advanced chronic infection is that the kidney is left with but a narrow margin of the remarkable tendency to speedy recovery exhibited by a kidney which becomes acutely infected in the course of sudden ureteral block of recent origin. To subject such patients to prolonged cystoscopic treatment may only result in losing the small chance of bringing about renal recovery.

(4) *General Health of the Patient* Elderly, debilitated men may not tolerate instrumental manipulations well, and severe clinical reactions may result. Some patients are more susceptible to febrile reactions following manipulative procedures, and once a severe febrile reaction has occurred, further instrumentation must be considered hazardous.

Moore¹² states that if infection is acute, severe, and characterized by repeated rigors, hyperpyrexia, and leukocytosis in the presence of an obstructing calculus, prompt surgical interference, with establishment of free drainage, may become a life-saving measure.

However, in order to prepare a ureteral calculus patient for operation we have at times used an indwelling ureteral catheter, which is of inestimable value in bringing about the quiescence of a septic course.

In elderly patients, associated pathology, such as prostatic hypertrophy, makes manipulative procedures technically difficult and febrile reactions more likely to occur. In such cases, operation may be the procedure of choice. To use more conservative methods may produce prolonged sepsis, which, in turn, may result in precipitation of cardiorenal failure.

In small children, due to technical difficulties, inability to secure good cooperation, and the necessity of repeated anesthesia, I believe open operation is the procedure of choice.

Transurethral Manipulations—In our experience the use of single and multiple catheters has been most successful, with minimal complications. There is some difference of opinion regarding the value of mechanical stone removers. We agree with Coppridge,¹³ who believes their use should be restricted to

stones in the lower third of the ureter (Fig 2) Although it requires more patience on the part of the surgeon and the patient, it is usually safer to continue with repeated manipulations and dilations with catheters than to attempt forcibly to remove the stone by any method employing traction

Recent reports in the literature reemphasize to us the importance of conservative procedures Perforation of the ureter has been reported by Council, ¹⁴ Rusche and Bacon, ¹⁵ and Vickery ¹⁶ Wishard ¹⁷ has reported a case of incarceration of a stone basket in the ureter due to a broken wire

The large number of instruments available today for the removal of stones in the ureter attest to the fact that no one instrument or method is suitable in all instances

Our current treatment of upper and midureteral stones is, in the absence of complications, a policy of watchful waiting If the calculus is 1 cm in diameter, or less, and is moving spontaneously down the ureter, manipulative treatment is delayed until the stone reaches the pelvic portion

Then the use of multiple catheters or a basket extractor is advised If the stone in the upper or midureter is producing complete obstruction, as evidenced by intravenous urography, then surgical intervention is advocated

Calculi in the intramural segment of the ureter present a characteristic picture on cystoscopic examination There is a bulging immediately above the ureteral orifice and an area of bullous edema about the orifice itself In this group a meatotomy can be performed and the stone withdrawn by use of the spiral extractor

If the intravenous urogram demonstrates considerable dilatation of the ureter above the calculus, only a meatotomy is performed, and manipulation is avoided In such instances manipulation may result in dislodging the stone, which may slip up to the kidney pelvis Prostigmine is used for a period of 24 hours to aid in the expulsion of the stone

Although we are very enthusiastic regarding manipulative management of ureteral calculi, it is our impression that this method may be advocated too extensively, and that it is frequently employed in cases where surgical intervention would lessen the hardship on the patient and be attended with a lower mortality and morbidity

Operative treatment—Spinal anesthesia is the anesthesia of choice for the surgical removal of stones from the ureter Immediately before operation it is advisable to check the location of the calculus roentgenographically This is a

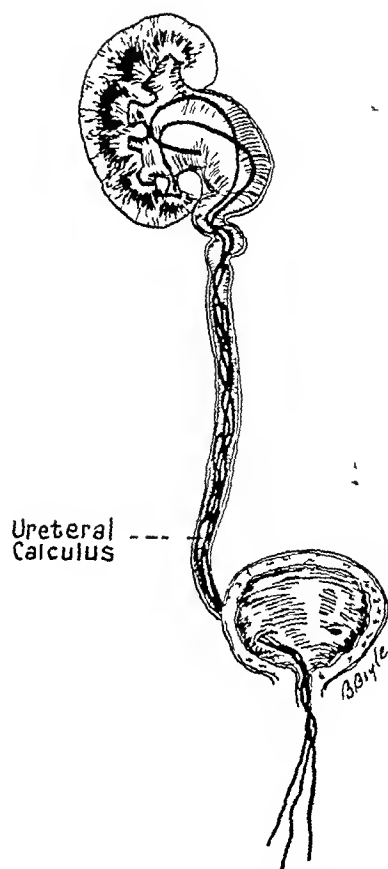


FIG 2—Multiple ureteral catheters for the removal of stones in the lower ureter

fundamental rule, but too frequently it is omitted and the surgeon finds that the stone has slipped into the bladder or back into the kidney during the night before operation. Such errors of omission are inexcusable and subject the patient to needless loss of time and hazards of operation.

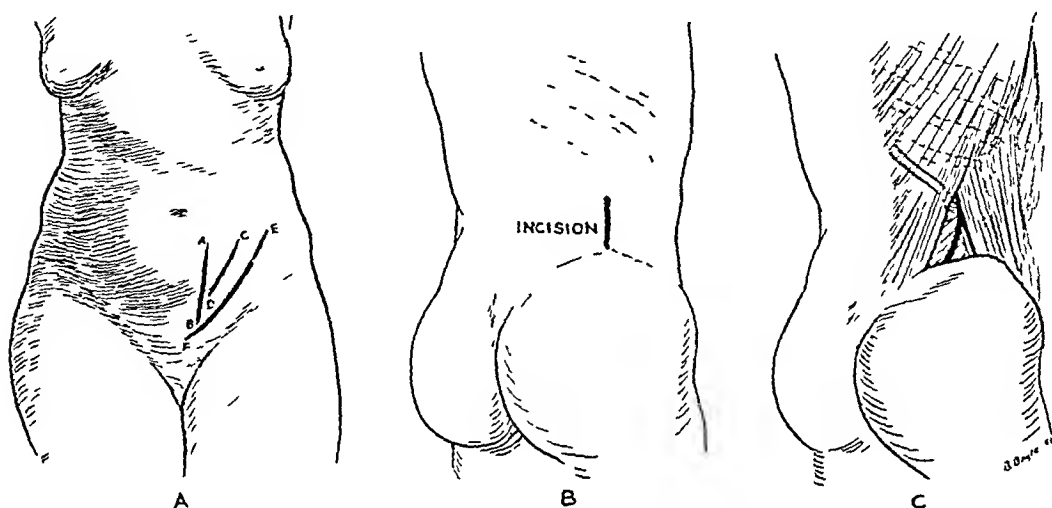


FIG 3—Incisions for removal of calculi in various portions of ureter (A) Stones in lower ureter, (B) stones in midureter, (C) stones in upper ureter

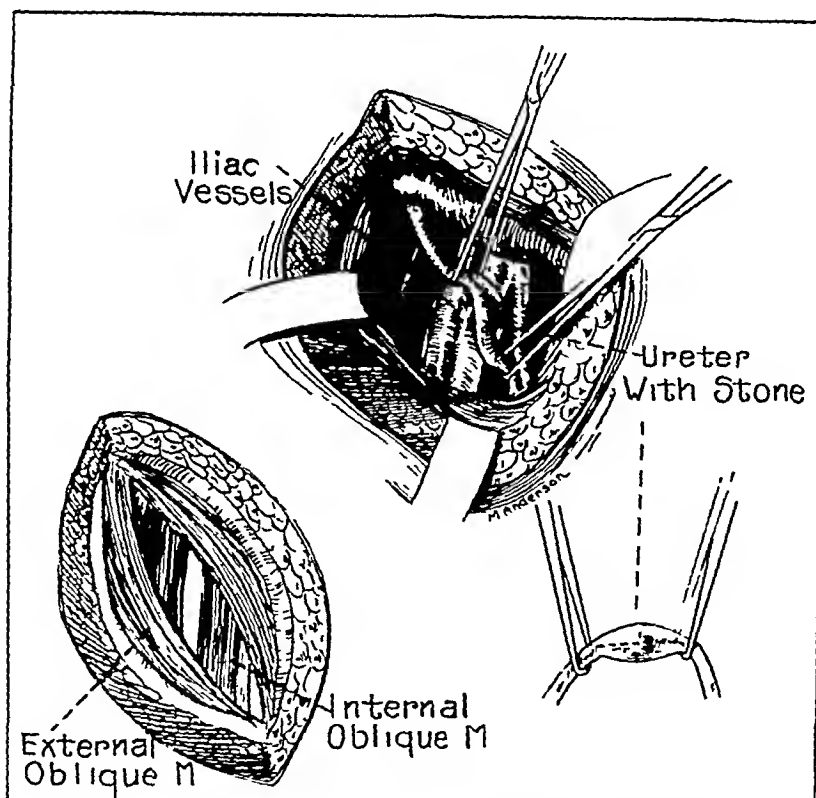


FIG 4—Technic for removal of calculus in lower ureter

A muscle-splitting operation and extraperitoneal approach are utilized in removing stones from every point of the ureter (Figs 3, 4, 5). The type of approach reduces pulmonary and circulatory complications, in view of the fact that patients are ambulant in five or six days. Incisional herniae are also reduced by this procedure.

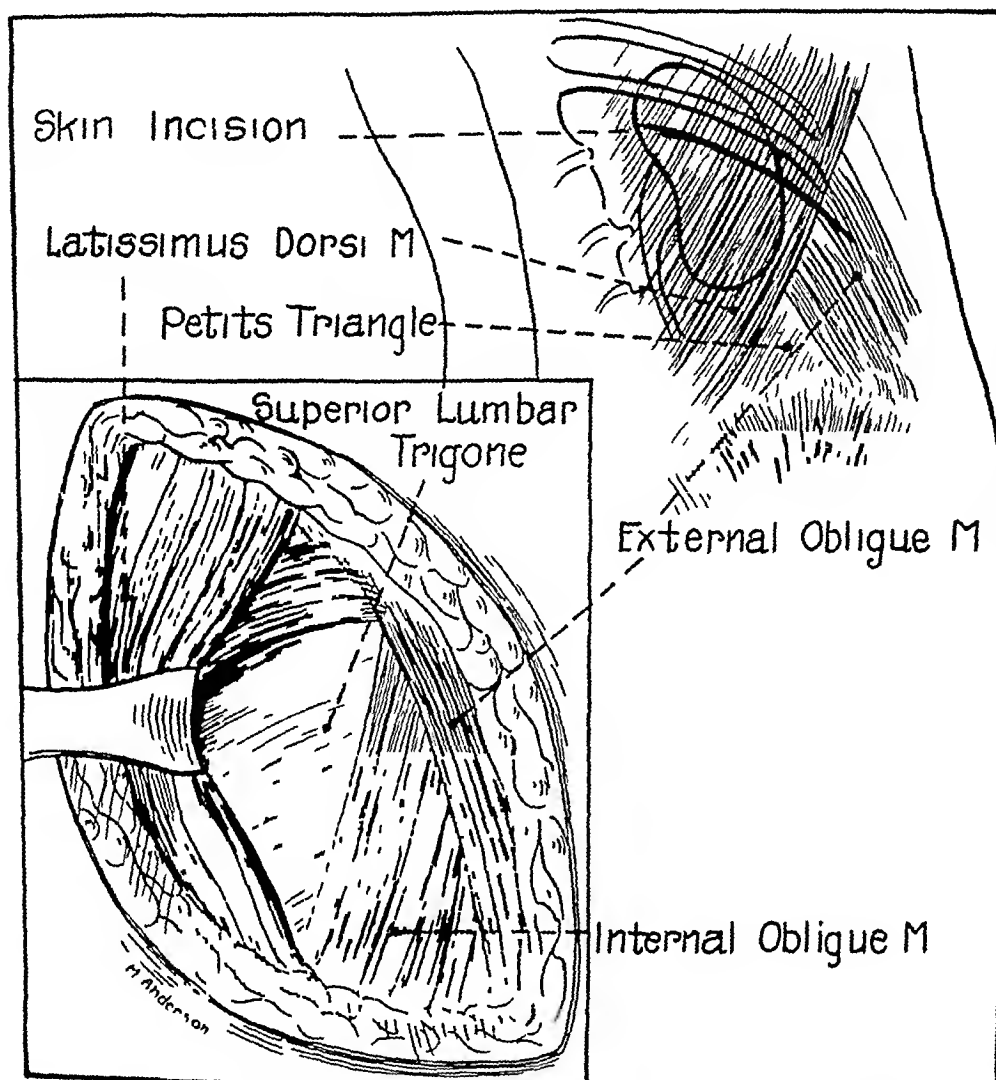


FIG 5—Incision for removal of stone in mid and upper ureter

There is one operative procedure for the removal of a stone from the lower ureter that has received but scant attention. This is vaginal ureterolithotomy. If the calculus can be palpated upon vaginal examination it may be readily removed by this route (Figs 6, 7, 8). We have observed no fistula formations, or other complications, following this surgical procedure.

Complications must be considered when methods of removing calculi are carried out. The choice between radical and conservative treatment of the hydronephrotic kidney is influenced upon the extent of renal function impairment and the status of the other kidney. A draining ureteral fistula, or a pyonephrotic kidney may make nephrectomy or nephroureterectomy imperative. However, many kidneys with varying degrees of hydronephrosis will

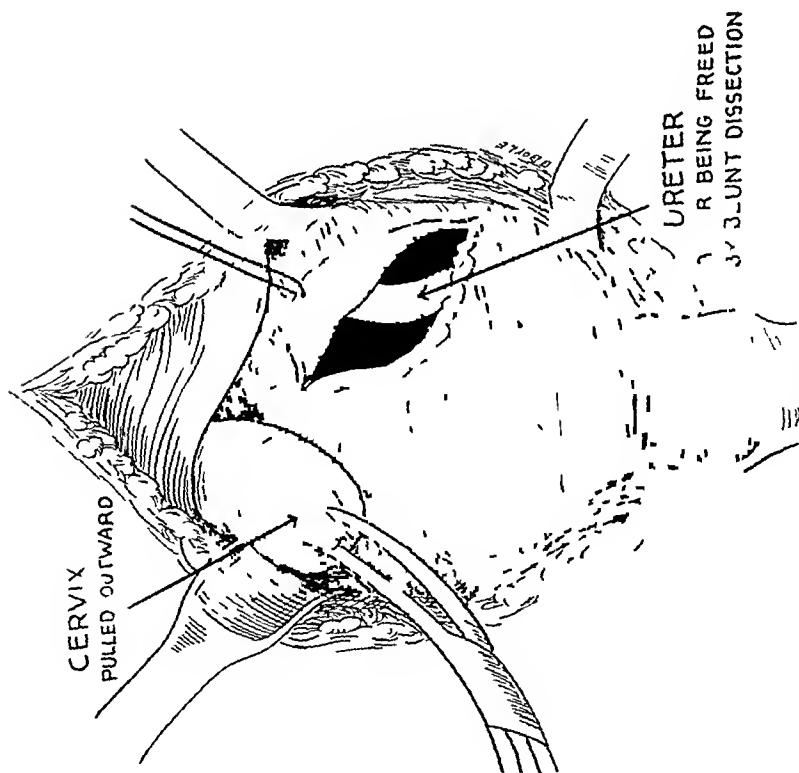


FIG 6—Vagino-ureteral lithotomy with exposure of ureter

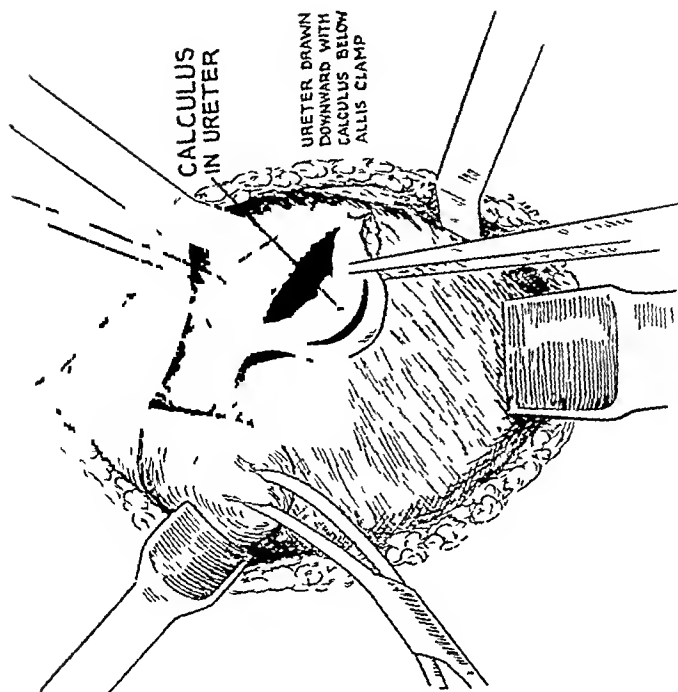


FIG 7—Removal of calculus from ureter

return to an amazingly good state when the obstruction is removed and drainage established

Certainly, dogmatic statements specifying indications are unwarranted, but in our experience operation has been resorted to for the following reasons (1) repeated failure of manipulative methods, (2) impassible obstructions due to stones that cannot be moved, (3) renal infections which endanger the life of the patient by temporization, (4) associated pathology which makes instru-

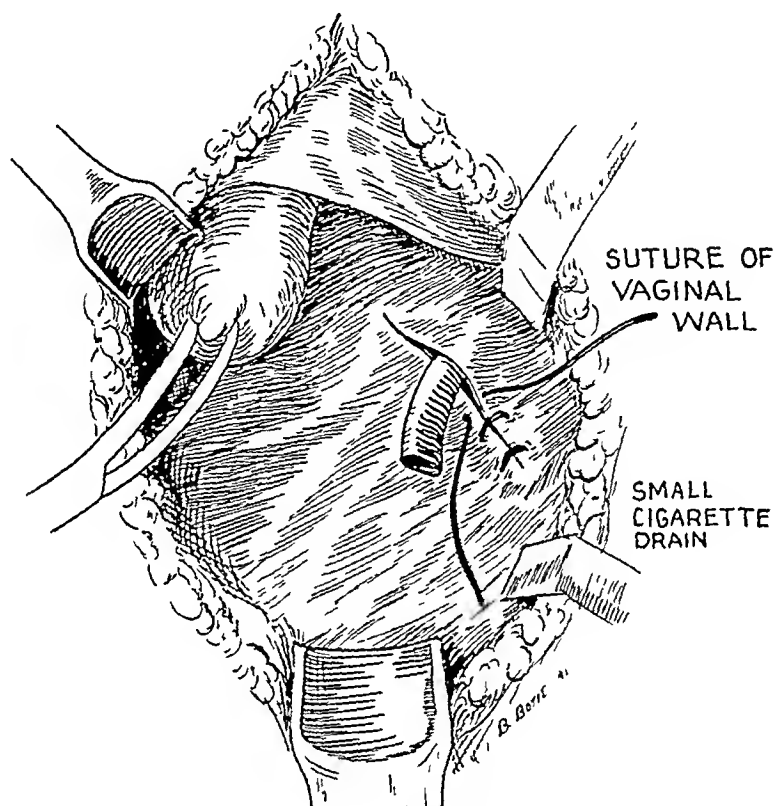


FIG 8—Closure of incision in vaginal wall

mental attempts technically impossible (urethral strictures, hypertrophy of prostate, *etc*), (5) upper urinary tract pathology, which itself requires surgery, and (6) patients who cannot tolerate transurethral manipulation

During the past decade three series of ureteral stone cases have been reported at Cleveland Clinic (Table IV)

TABLE IV
COMPARISON OF FINDINGS IN THREE SERIES OF CASES

Series	Cases	Spontaneous Expulsion %	Expelled after Manipulation	Surgical Interference
1-1939 ¹⁰	251	43-17 1%	37-14 7%	171-68 4%
2-1942	350	66-18 9%	56-16%	228-65 1%
3-1946	256	29-11 3%	149-58%	78-30%

CONCLUSIONS

- 1 Investigation of the numerous etiologic factors in each ureteral stone case is important
- 2 The plan of management for each case must be individualized

3 In our experience ureteral catheter manipulations are superior to mechanical stone extractors, although the latter are a valuable adjunct in many instances

4 The current trend at Cleveland Clinic in the treatment of ureteral calculi is definitely toward conservative management by manipulation rather than by open surgery

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CAROTID BODY TUMORS*

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CAROTID BODY TUMORS rarely are seen on the surgical services of most hospitals. In 1935, Peterson & Meeker¹ presented before the New York Surgical Society a series of 18 such tumors, collected from seven hospitals of New York City. At that time, none were listed from Memorial Hospital. Since 1937, ten patients have been treated for carotid body tumors, on the Head and Neck Service of this Institution.

The first report of a tumor of carotid body origin to appear in the American literature was that by Scudder,² in 1903. Since then a survey of the literature shows an accumulation of nearly 300 tumors of this type. Many single case reports have been listed. The largest individual series has been that from the Mayo Clinic, published in 1941, by Harrington, Clagett and Dockerty.³ Twelve patients of their series of 20 had been reported previously by Rankin and Wellbrock.⁴

As the anatomy and histology of the carotid body have been described frequently they will not be discussed at this time.

Embryology—There is no unanimity of opinion as to the developmental anatomy of the carotid body. Theories of origin are that it arises from (1) the epithelium of the pharynx, (2) the endothelium or adventitia of the carotid artery, and (3) the embryonic ganglion cells of the sympathetics.

Function—The exact function of the carotid body still has not been established definitely. For many years there was believed to be an internal secretion from this gland. The chromaffin granules of the carotid body were considered as at least precursors of epinephrine, but this theory now has been disproved. In the human, the carotid body can be found in not more than 25 per cent of autopsy specimens.

An article on the functions of the carotid and aortic bodies from the Department of Pharmacology of the University of Pennsylvania was published in 1940. The authors, Schmidt and Comroe,⁵ have made extensive investigations of the functions of the carotid body in the dog. They conclude that the major function of the carotid body, and probably of the aortic bodies, is due to the presence within them of chemoreceptors which respond to chemical changes in the blood.

Reflex receptors in the carotid body seem to be specialized to respond to changes in the oxygen tension of the blood, whereas cells of the respiratory center respond to changes in the carbondioxide tension. The hydrogen ion may be an important factor in regulating chemoreceptor activity. Schmidt and Comroe's⁵ experiments indicate that "the activity of the receptors can be

* Read before the New York Surgical Society, April 10, 1946.

altered by a variety of chemical agents including all the usual products of tissue metabolism . . . Recent workers agree that carotid bodies and aortic bodies are not "chromaffin" in the usual sense, which is further evidence that they may not be related to the sympathetic nervous system. According to the Mayo Clinic report of 1941,³ "the carotid body is no longer considered part of the internal secretory system and the function whatever it may be, is negligible since both carotid bodies can be enucleated without any manifest symptoms."

Pathology—Most carotid body tumors appear to be benign in nature, yet some authors have stated that as many as 50 per cent are malignant. Although eight of the 18 tumors of the series from New York Hospitals had been diagnosed as malignant, Peterson and Meeker¹ considered their malignant status to be uncertain. In the Mayo Clinic Series ten of the 20 tumors were found on microscopic examination to be malignant. In the Memorial Hospital Series of ten patients, five tumors were reported to be malignant and five were benign. In the case of bilateral tumor, both were malignant.

Microscopically, the benign tumors are found to be extremely vascular. Small cells predominate in a uniform pattern and fibrosis is less pronounced. In the more malignant group pleomorphism occurs. The cells contain small nuclei. Invasion of the capsule and of lymphatics is found. A few tumors of this group are extremely fibrotic in character.

Incidence—Carotid body tumors occur most frequently in the third and fourth decades of life, with no predominance in either sex. The present series of ten patients is composed of seven males, the youngest being 24 years of age, the oldest 57 years, and three females, the youngest 20 years of age and the oldest 31 years. The average age for the entire group is 36 years. In this group six had tumors on the left side, three on the right side, and one was bilateral.

Symptomatology—The usual complaint of the patient suffering from a carotid body tumor is the presence of a "mass" or "lump" in the neck. Frequently it has been found that the tumor had been observed first some years before and that the patient came for treatment because he believed the mass had increased in size. This was the only symptom in six patients of the present series. In three patients, however, the presence of a pharyngeal mass was the chief complaint. Although a similar enlargement was found on examination of a fourth patient he was not aware of its presence. The average duration of the presence of the tumor in the neck for this group was five years. On admission, two patients were found to have a Horner's syndrome and two had paralysis of a vocal cord. Another patient of the group associated systemic symptoms of malaise, mild headaches, depression and occasional febrile reactions with the increasing size of the neck tumor, but it seems unlikely that these attacks were caused by the tumor itself.

Diagnosis—Gordon-Taylor⁶ has said that carotid body tumors are rarest of all tumors in the neck. In the period of nine years, when the present series of ten carotid body tumors was being accumulated, an average of 1,200 new patients were examined in the Head and Neck Department of Memorial Hospital. The possibility of an unexplained cervical growth being a carotid body

tumor is evidently small. However, in the present series, four correct clinical diagnoses were made. In three of the four, the diagnoses were confirmed pathologically by aspiration biopsy. In the remaining six patients of the series, aspiration biopsy was performed, but it was impossible to obtain sufficient tissue for diagnosis. The first patient with a carotid body tumor was admitted to the clinic in 1937. An aspiration biopsy was performed and an erroneous diagnosis of "carcinoma, possibly thyroid" was made. However, when the second patient in the series appeared, a clinical diagnosis of carotid body tumor was made and confirmed by pathologic examination. It has been stated by some authors that aspirating such a vascular tumor would be an extremely hazardous procedure but this supposition has not been proven at Memorial Hospital.

TREATMENT

Most authors agree that carotid body tumors should be removed surgically. Yet, the necessity of ligation of the common and internal carotid arteries occurs so frequently that because of the high postoperative mortality it might be better to refrain from this procedure, were it possible to be certain of the benign nature of the tumor. The possibility of a benign tumor later becoming malignant must be kept in mind however. Goodof and Lischer⁷ have published an article describing a carotid body tumor in a 47-year-old Negro. The cervical growth measured six centimeters in diameter. The blood Wassermann was positive, and antiluetic therapy was instituted. After two months of treatment the patient failed to return. Fifteen years later he was readmitted to the same institution in cardiac failure. The cervical tumor had grown to twice the size of that recorded on the first examination. At autopsy, a tumor, similar in character to the carotid body tumor was found in the pancreas. Mitotic figures were present in both tumors. The authors considered the neoplasms to be multicentric in origin. The cause of death was unrelated to the presence of either tumor.

Mortality rates for surgical excision of carotid body tumors, with ligation of the common and internal carotid arteries, are reported from 0 to 100 per cent. Such results demand careful consideration before an operation is undertaken which may require resection of the carotid arteries. Postoperative disabilities are estimated to be as high as 83 per cent. They consist of temporary or permanent hemiplegia and the effects of injuries to the cervical sympathetic, hypoglossal or vagus nerves.

In the present series of ten patients the carotid body tumor was resected without injury to the arteries in only three instances. In the other seven patients it was necessary to include the carotid arteries in the resection of the tumor. There were four postoperative deaths, occurring in 30 hours, two days, five and five days, respectively. Hemiplegia preceded death in each instance. In one patient ligation of the common carotid caused a convulsion, followed by hemiplegia on the operating table, although a Matas' band had been applied for compression of the common carotid three days before the major operation.

was performed. In this case, it seems likely that cerebral anemia caused the convulsion and hemiplegia, though the patient was only 31 years of age. The postoperative mortality rate for the seven patients requiring removal of the carotid arteries is 58 per cent. Of the total group of ten it is 40 per cent.

Recurrence of the tumor takes place in about seven per cent of the patients, according to Phelps and Snyder.⁸ Recurrences are possible when the capsule is invaded or the entire tumor is not removed. The latter condition may be the result of attempting to dissect a closely adherent tumor from the arterial wall. One tumor of the present series recurred and was again removed surgically. The patient died at home with extensive recurrences in the cervical region, but unfortunately an autopsy could not be obtained.

Fatalities following carotid ligations are usually the result of insufficient collateral cerebral circulation or an ascending thrombosis in the internal carotid artery.

External compression of the common carotid artery, as described by Matas,⁹ is undoubtedly of value in testing for the efficiency of the collateral cerebral circulation. Dandy¹⁰ has emphasized the fact that if a patient cannot withstand the Matas test an immediate total occlusion of the carotid artery should not be done.

The use of increasing periods of daily external compression may be of some aid in improving the compensatory flow of blood through the circle of Willis but some authors question the value of this procedure.

Dandy¹⁰ has stated that "a high percentage of patients, regardless of age (but certainly increasing with age) will not tolerate total ligation of the carotid, but by partial closure of the carotid the cerebral collateral circulation becomes quickly established, and complete closure can be safely concluded later." He advocates the use of a double strip of fascia lata to attain partial closure of the common carotid artery.

An ascending thrombosis in the internal carotid artery theoretically is caused by the trauma to the intimal wall by the application of the ligature. This injury may be prevented by the interposition of a strip of fascia lata between the ligature and the wall of the artery, as advised by Dandy.

Heparin has been used in four patients on the Head and Neck Service following ligation of the carotid arteries during the removal of the metastatic cancer. No fatalities have resulted. There was one disability which consisted of temporary partial paralysis of an upper extremity. In this patient fascia lata had also been used in ligation of the internal carotid. Heparin was used also in three instances of this series of carotid body tumors. In one patient there were no postoperative complications. In the other two patients hemiplegia had already developed before the heparin was administered, and, therefore, the drug was ineffective.

CASE REPORTS

Case 1—W. M., a 47-year-old white male, was admitted to the Clinic, in June, 1937, and had been aware of a "lump" in the left neck for ten years. It had been increasing in size for the last three years. Examination revealed an 8-cm., smooth ovoid mass over the left carotid bulb. The patient also had a constriction of the left pupil.

CAROTID BODY TUMORS

Tissue was obtained for pathologic examination on the second aspiration. It was diagnosed as carcinoma—possibly of thyroid origin.

In view of the pathologic report, a course of roentgenotherapy was started. After two-thirds of the treatments were administered without regression of the tumor, roentgenotherapy was abandoned in favor of surgery.

Operation was performed August 27, 1937, under local anesthesia. The tumor, at operation, could not be dissected free of the carotid arteries. The common carotid was compressed for 20 minutes without apparent ill effect. Then all three carotids were ligated and removed with the tumor. The hypoglossal and superior laryngeal nerves were sacrificed.

There were no postoperative complications. The Horner's syndrome persisted. The 9th, 10th, and 12th cranial nerves showed evidence of paralysis.

The pathologic report was carotid body tumor. No malignant changes were noted.

Case 2—A P, a 24-year-old white male, was admitted to the Clinic, January, 1940, and had had a "lump" in the left neck for two years, and associated systemic symptoms of malaise, headache, depression and occasional febrile reactions, with the increasing size of the tumor. Examination revealed a 5-cm ovoid mass beneath the angle of the right lower jaw. The clinical diagnosis was Hodgkin's disease or carotid body tumor.

Sufficient tissue for pathologic examination was obtained on the third aspiration. It was reported as carotid body tumor.

At operation, January 28, 1940, under local anesthesia, an intricate plexus of blood vessels was found covering the tumor mass, and the common carotid artery, and extended over the sternomastoid muscle and the strap muscles of the neck. A Crile clamp was placed on the common carotid artery. After 15 minutes ligation was completed. The sympathetic cervical chain was sacrificed.

The postoperative course was uneventful. A Horner's syndrome was the only abnormality noted.

Pathologic study revealed carotid body tumor, with malignant changes. Eleven months after operation the patient returned with a node at the operative site. He did not return for another six months. At that time, the mass measured 5 cm, and presented in the pharyngeal space. Aspiration biopsy suggested recurrence.

Second operation—October 9, 1941. The second operation was done under sodium pentothal. The mass was intimately associated with the wall of the esophagus and extended to the level of the first cervical vertebra. Eight gold seeds (11 mc) were placed at this level. Pathology reported the growth as recurrent carotid body tumor, with vein and node invasion.

There were no immediate postoperative difficulties. Six months later, many large nodes were found in either side of the neck. The patient complained of headache, double vision, and generalized symptoms. The 6th cranial nerve was involved, and it seemed likely that the disease had entered the base of the skull. The patient died at home a year after the second operation, two years after the first. No autopsy could be obtained.

Case 3—A D, a 57-year-old white male, was admitted to Clinic in November, 1940. He complained of a mass in the left neck of 14 years' duration, which had recently become tender. Examination revealed a smooth ovoid mass of 5 cm over the carotid bulb. Aspiration biopsy was negative. A clinical diagnosis of branchiogenic cyst was made. Three more attempts were made unsuccessfully to obtain diagnostic tissue by aspiration. Clinical diagnosis of carotid body tumor was made at this time.

Operation was performed under local anesthesia, November 22, 1940. The tumor was removed without ligation of the carotid arteries or sectioning of nerves.

The pathologic report was carotid body tumor, without evidence of malignant change.

Case 4—M B, a 44-year-old white male, was admitted, July, 1940, complaining of a "swelling" in the left neck of six months' duration. Examination revealed a smooth ovoid

mass of 4.5 cm over the left carotid. It had the consistency of a metastatic node. Because the left tonsil was enlarged and firm, the patient was advised to enter the hospital to have it removed for biopsy. This the patient refused to do.

It was six months before he returned. At that time, because of the slow growth of the tumor, a diagnosis of carotid body tumor was considered. The original aspiration biopsy was reviewed and the diagnosis of carotid body origin was considered possible. A second aspiration at this time gave a more typical picture of a carotid body tumor.

Operation was performed, under local anesthesia, in July, 1941. A Crile clamp was applied gradually over a period of eight minutes, without any ill effects. All three carotids were ligated and removed with the tumor. The patient's immediate postoperative condition seemed good, but he never regained complete consciousness, and developed hemiplegia within 12 hours. He died on the 5th postoperative day.

The pathologic report was carotid body tumor, with malignant changes.

Case 5—A C, a 31-year-old white male, was admitted to Clinic in February, 1942. He complained of a mass of the left neck of three years' duration. Examination revealed a firm mass of 6 cm in the left upper neck. The left pharyngeal wall presented a non-ulcerating, bulging mass extending from the nasopharynx to the tip of the epiglottis. Both masses seemed to be a part of the same tumor. A provisional diagnosis of carotid body tumor was made, and confirmed by aspiration.

Operation—March 30, 1942. Under local anesthesia, the common carotid artery was compressed by a Matas band. This operation was preceded by three days of intravenous sodium thiosulfate (1 gm in 10 cc daily). No symptoms resulted from the carotid compression.

Four days later, April 3, 1942, the tumor was removed. The procedure was carried out under local anesthesia. The common, external and internal carotid arteries were ligated and the vagus and hypoglossal nerves cut. Fifteen minutes after the carotid was sectioned, the patient had a convulsion, and a complete right-sided paralysis developed. There was no thrombus in the common carotid at this time. Hemiplegia was probably due to incomplete blood supply to the brain. The patient died 48 hours postoperatively.

Pathologic report on the operative specimen was carotid body tumor, with no suggestion of malignant change. Permission for autopsy could not be obtained.

Case 6—F S, a 31-year-old white female, was admitted to the hospital, in April, 1942. She had been referred by her local physician for removal of a tumor beneath the right lower jaw. Examination revealed a firm ovoid node, about 2.5 to 3 cm in size. Aspiration biopsy was attempted but no tissue was obtained.

The tumor was removed under local anesthesia, April 24, 1942. A great deal of fibrous tissue surrounded the mass. In dissecting around the carotid bulb the thinned-out artery wall was irreparably damaged. A sponge clamp applied to the common carotid artery early in the operation had been in place 45 minutes when the hemorrhage occurred. There were no circulatory disturbances. All carotid arteries were ligated.

There were no postoperative difficulties until 36 hours after operation, when the patient developed a right hemiplegia. Heparin had not been administered until the paralysis developed. The patient died on the 5th postoperative day. Permission for autopsy was not obtained.

The pathologic report was carotid body tumor. It was benign.

Case 7—M V, a 29-year-old white male, was admitted to the Clinic, in July, 1943. He complained of a "swelling" in the left neck of one year's duration. He had previously been treated in another hospital for tuberculous osteomyelitis. Examination revealed a node, 3 cm in diameter, in the left submaxillary region and a smaller node anterior to it. The provisional diagnosis was tuberculous adenitis.

The tumor was removed, August 8, 1943, under local anesthesia, without ligation of the carotids or sectioning of nerves.

There were no postoperative complications. The patient was free of disease when last seen.

The pathologic report was carotid body tumor. It was benign.

Case 8.—J. D. V., a 20-year-old white female, was referred to the hospital from a local clinic, in September, 1944. She had noticed a small "lump" beneath the angle of the left lower jaw a year and one-half previously. A biopsy had been taken from the nasopharynx and reported as transitional cell epithelioma, Grade 2. A few roentgen ray treatments had been administered before she was referred to Memorial Hospital.

Examination revealed a bulging, nonulcerating mass of 4 cm. in the posterolateral pharyngeal wall, which seemed a part of the mass present in the right neck. The patient had a right Horner's syndrome. The nasopharyngeal biopsy from the local clinic was reviewed by the Pathology Department, but the diagnosis of epithelioma could not be confirmed. Two attempts to obtain tissue by aspiration were unsuccessful.

Operation was performed, September 25, 1944, under sodium pentothal. A tracheostomy was established first. The tumor, measuring 6 cm., was removed. The vagus and hypoglossal nerves were sacrificed. The tumor was dissected free of the carotid arteries. Aside from signs of vagus and hypoglossal paralysis, there were no postoperative sequelae.

The pathologic findings were carotid body tumor and lymph node, showing metastasis or extension. The tumor was malignant in character. She recently reports improvement in difficulty in swallowing. There has been no recurrence of the disease.

Case 9.—A. T., a 20-year-old white female, was admitted to the Clinic, in June, 1943, for a "lump" in the right neck of two years' duration. Biopsies of the tonsil and the neck node had been made at another hospital. A telephone report of hyperplastic lymphoma of the tonsil was received, but no report concerning the neck node could be obtained. Examination revealed a mass, 5 cm. x 2.5 cm., in the right tonsillar fossa. The right vocal cord was paralyzed and the right arytenoid edematous. A large subdiaphragmatic node, 4 cm. x 3 cm., was present on the right side. Other smaller nodes were present on both sides of the neck. A provisional diagnosis of lymphosarcoma was made. Chest roentgenograms and blood studies were normal. The Kline test was three plus.

Attempts at aspiration and open biopsy of the neck node yielded no diagnostic tissue.

For several months the patient received treatment for lues and active gonorrhea at another hospital.

Operation was performed, March 19, 1945, under sodium pentothal, with a tracheostomy tube in place. The vagus and hypoglossal nerves were sacrificed. The carotids were sectioned. The mandible was sectioned obliquely at the angle to permit extending the operation into the pterygomaxillary space.

Heparinization was begun postoperatively and was maintained for three days. No hemiplegia developed. Hoarseness continued. The patient had considerable difficulty in swallowing.

The pathologic findings were carotid body tumor, with marked fibrosis and malignant changes. There has been no recurrence of the disease to date.

Case 10.—E. B., a 52-year-old male, was admitted to the Clinic with a mass in the right neck which had been noted first 13 years previously. It had been treated by local physicians, first, as an abscess by excision, which caused profuse bleeding, then, as tuberculous adenitis by roentgenotherapy. In May, 1945, he was referred to Memorial Hospital. Examination showed a 6-cm. tumor in the right lateral pharyngeal wall. It pulsed on palpation. A 3-cm. mass was present in the region of the right carotid bulb. A similar mass was present over the left carotid bulb. There was paralysis of the right side of the larynx. Only blood was obtained on aspiration. The clinical impression was schwannoma.

Operation was performed under local anesthesia, July 15, 1945. It was necessary to ligate the carotids and sever the vagus. Following this procedure the blood pressure

dropped and respirations ceased. Artificial respiration was administered. The patient was returned to the ward in poor condition, and was placed in an oxygen tent. There was evidence of left-sided hemiplegia immediately following operation. Heparin was administered postoperatively. On the evening of the day of the operation paralysis developed on the opposite side. He expired 30 hours postoperatively.

The pathologic findings from the operative and autopsy specimens were bilateral carotid body tumor, with structure in places malignant in each of the tumors.

TABLE I
SUMMARY OF MEMORIAL HOSPITAL
SERIES OF CAROTID BODY TUMORS
1937-1945

I	Incidence	
	A Number of patients	10
	1 Male	7
	2 Female	3
	B Average of patients	36 years
	1 Oldest	57 years
	2 Youngest	20 years
II	Distribution	
	A Right-sided	3
	B Left-sided	6
	C Bilateral	1
	D Recurrent	1
III	Symptoms	
	A Cervical tumor	6
	B Cervical and pharyngeal tumor	4
	C Nerve involvement	
	1 Vagus	3
	2 Cervical sympathetic chain	2
	3 Hypoglossal	0
IV	Diagnosis	
	A Correct preoperative—clinical	4
	B Correct preoperative—pathologic	3
V	Treatment	
	A Preoperative roentgenotherapy before diagnosis of carotid body tumor	3
	B Surgical operation	10
	1 Carotid arteries ligated	7
	a Total	7
	b Partial	1
	2 Nerves were sectioned	
	(a) Vagus (2 right, 2 left)	4
	(b) Cervical sympathetic chain	2
	(c) Hypoglossal	4
VI	Pathology	
	A Benign	5
	B Malignant	5
VII	End-results	
	A Number living	5
	B Death from disease	1
	C Postoperative death (40%)	4
	D Rate of mortality following carotid resection	58%

CONCLUSIONS

Carotid body tumors are difficult to diagnose preoperatively. Aspiration biopsy offers a possibility of obtaining enough tissue to permit histologic diagnosis of carotid body tumor, although the pathologist usually is unable to determine from the small amount of tissue available, whether or not the tumor is malignant.

The high mortality of ligation of the common and internal carotid arteries is caused either by inadequate collateral cerebral circulation, or to an ascending thrombosis of the internal carotid artery. Hemiplegia occurs immediately in the former incidence, and in the latter 30 to 36 hours postoperatively.

If one could be certain that a carotid body tumor was benign in nature, it might be wise to keep the patient under observation and refrain from the use of surgery unless the increasing size of the tumor caused symptoms of pressure.

When a carotid body tumor is to be removed surgically, the patient should be hospitalized for a period of observation and preparation for operation. The Matas test should be utilized to determine collateral cerebral circulation and, if necessary, a partial occlusion should precede the total occlusion and removal of the tumor.

The use of heparin postoperatively is suggested as a possible means of preventing an ascending thrombosis in the internal carotid artery.

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MESENCHYMOMA, THE MIXED TUMOR OF MESENCHYMAL DERIVATIVES*

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MOST OF THE TUMORS which presumably are formed from the cellular derivatives of the mesenchyme assume a guise which should enable one to recognize their nature microscopically and to label them with a properly descriptive name. It is important that this be done, for the different types of tumors are affected by irradiation in varying degrees and pursue biologic courses which differ one from the other so that the treatment best designed to produce favorable results is not the same in every case. During the past 75 years knowledge concerning those tumors, which are composed of cell masses more or less resembling the various derivatives of the supportive and reticulo-endothelial tissues, has slowly accumulated and criteria now exist for recognizing malignant neoplasms composed of lipoblasts, synovioblasts, rhabdomyoblasts, and several others, and the terms liposarcoma, synovial sarcoma, rhabdomyosarcoma, etc., can be used instead of such vague and inaccurate names as spindle-, round-, and giant cell sarcoma. Correct labelling has permitted the accumulation of case histories of the tumors and there now exists a body of experience which serves as a guide to treatment.

Unfortunately these tumors of mesenchymal derivation do not always grow in a pure form. In the first place their cells may lose the special features which characterize them as formers of fat, muscle, synovial tissue, etc., and take on the function of making connective tissue fibers. In tumors like the synovial sarcoma such cells are always present and form an integral part of the tumor (Haagensen and Stout, 1944). In others, such as the liposarcoma, this feature is found in only a few of the neoplasms. In an occasional neoplasm, bone, cartilage, or both of them in differentiated form, may be found in the framework of the tumor as was the fact in Case 40 of the group of liposarcomas reported by the writer in 1944.

Another confusing situation arises when a preexisting lesion composed of heterotopic tissue suddenly develops a malignant neoplasm. The best example of this is the development of a sarcoma in an area of myositis ossificans. When this occurs, the differentiated bone and cartilage of the myositis ossificans may give rise to pure osteogenic or chondrosarcoma (Mallory 1933) or they may be intermingled with a malignant mesoblastic tumor of some unrelated type such as a reticulum cell sarcoma, as occurred in one of our cases. Since some atrophic or degenerate striated muscle fibers may also still be present, the resulting admixture of all these may provide a most confusing and complex histologic picture but because the bone and muscle are not neoplastic

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and do not play an active rôle in the neoplasm, it cannot be considered as a true mixed tumor

In addition to such vagaries of the growth of single cell tumors with metaplasia, there occur a variety of tumors in various parts of the body in which two or more tissue forms participate in the formation of both benign and malignant tumors. Many of those are composed of both epithelial elements as well as mesodermal derivatives such as the adenofibromas of the breast, the adenosarcomas of the kidney and the mixed tumors of mucous, salivary, lacrymal and sweat glands, to mention only three familiar types. There are also a variety of others which seem to be purely mesenchymal and it is upon these that attention will be focussed in order to emphasize the fact that they may be found in regions of the body not commonly associated with them.

Most of these mixed mesenchymal tumors probably are initiated as a result of developmental faults and they may therefore be regarded as dysontogenetic growths. In one tumor form capillaries, adipose tissue and smooth muscle are all present together. Such uncommon neoplasms are found usually in the muscles or subcutaneous tissues and either the blood vessels or the fat predominate with relatively small amounts of smooth muscle so that they are commonly labelled either hemangioma or lipoma (Stout, 1944). In a tumor of this sort described by Rocher and Uzac (1931) bone also was present. So far as my knowledge goes such tumors are always benign.

The benign hamartomas of the lung sometimes fail to contain any epithelial elements and are made up of differentiated bone, cartilage, fat and myxomatous tissue (McDonald et al 1945). There are also the fibrous and fatty pedunculated tumors of the skin which vary from tiny pedunculated growths to neoplasms of huge proportions. These are usually called fibrolipomas or simply fibromas or lipomas depending upon which of the two tissues predominates. In the urogenital tract there are many benign mesodermal mixed tumors which are believed to be congenital. For example, there are benign mixed tumors formed in the kidney composed of mixtures of smooth muscle, fibrous and adipose tissue. These have been collected by Colvin (1942), who suggests for them the infelicitous name of capsuloma because most of them are attached to the deep surface of the capsule. Belonging in the same general category are the peculiar lipomas of the kidney capsule which contain areas of bone marrow in an active stage of hematopoiesis (Stout, 1932). Takács' (1942) uterine tumor which he called mesenchymoma embryonale angioplasticum, Gaidner's (1940) fibromyoma angiomasum, Limburg's (1942) lymphangiocystic fibroma of the uterus are all examples of the benign mesenchymal mixed tumor.

In addition to these benign forms, there are also a number of malignant tumors of the urogenital tract which are made up of a mixture of mesenchymal derivatives. Dreyfuss and Lubash in 1940 described what they called a malignant mixed tumor of fourteen years' duration and recent rapid growth attached to the spermatic cord. It was excised and recurred at once, leading to a second excision in two months. It was composed of both osteogenic sarcoma

and liposarcoma Amolsch (1939), using the name mixed mesodermal tumor, described six cases of polypoid growths in the vagina and uterus of five adults and one child. One was not followed, one was symptom-free two years after the removal of a recurrence and the other four died of recurrences and metastases. These tumors were made up of myxoma, chondroblasts and rhabdomyoblasts. An example of a similar mixed mesodermal pedunculated tumor attached near the trigone of the bladder of an 83-year-old man has been recorded by Hirsch and Gasser (1944). It contained cartilage, osteoblastic tissue, myeloid cells and rhabdomyoblasts. The patient died five days after its removal. Other cases are referred to in their paper. The whole subject of the malignant mixed mesodermal tumors of the urogenital system has been comprehensively reviewed by McFarland (1935) who concludes that they can best be explained on the basis of dysontogenesis. Examples of similar growths in the female mammary gland without epithelial elements are discussed in the paper by Hill and Stout (1942). These cases have all been found in the urogenital tract and breast. One of the purposes of this paper is to emphasize the fact that malignant tumors of this variety are not confined to these tracts but have appeared elsewhere.

The cases of this sort to which attention is here directed are all potentially or actually malignant neoplasms composed of two or more cellular types any one of which, if taken by itself, might be considered a primary malignant neoplasm. It is unfortunate that proof of malignancy is lacking in all but three of these cases, yet knowing from experience the malignancy of the individual component parts of the other cases, it seems scarcely necessary to question their potential malignancy. As will be shown, every tumor differs from every other one in its cellular composition, they are alike only in the fact that all are actually or potentially malignant, all are mixed tumors compounded of cells and tissues of a variety ordinarily derived from primitive mesenchyme, not one of them can be fitted into the standard recognized varieties of sarcoma, and each one would have to receive a different compound name if they were to be designated by a term recording all of the component parts.

Table I shows the extraordinary breadth and variety of the tumor types found together in the eight cases. Almost all of the known varieties of malignant mesodermal neoplasms are represented with two cases showing five types—one showing four types, two having three types, and the rest two each. Perhaps one should not be too much surprised at these compounded growths. After all, the mesenchyme is an extremely versatile tissue, which in orderly development produces the normal prototypes of all of the tissues of which these malignant cells are the grotesque caricatures. It is surprising only, it seems to me, that there are not more tumors showing such admixtures. When one considers the performances of the tumoral derivatives of the neural crest which can reproduce in tumor form such mesenchymal tissues and cells as reticulin, striated muscle, fat, bone, cartilage and possibly kidney blastema, the productions of the mesenchymal cells seem the work of amateurs (Masson, 1938, Stout, 1946, 1947).

MESENCHYMOMA

Some of the reports from the literature dealing with isolated cases of this sort show that the authors usually recognized their complex nature and had thoughts about their origin somewhat similar to those expressed above. Spéder and Lafforet (1937) described a huge tumor of the posterior surface of the thigh which weighed 119 kilos and was composed of areas of lipoma, osteoma, chondrosarcoma and osteogenic sarcoma. It metastasized to the mandible where it grew as a fibrosarcoma. They recorded the fact that M. E. Polosson in his Thèse de Lyon, 1925, proposed for similar giant tumors the name "conjontivome" which he stated had long been applied to branchiomas of the face and neck. Spéder and Lafforet emphasize that these tumors are characterized by long slow growth and a sudden change to malignancy. Gilmour's

TABLE I—*Histopathologic Composition of Mesenchymomas*

Case	Sex	Age	Site	Composition										
				Fibrosarcoma	Myoma	Liposarcoma	Leiomyosarcoma	Rhabdomyosarcoma	Osteogenic sarcoma	Chondrosarcoma	Reticulum cell sarcoma	Hemangioma	Hemangiopericytoma	Hemangioendothelioma
1	M	77	Gluteal muscles	+		+	+		+					
2	M	45	Rectus fem muscle				+		+	+	+	+		
3	M	70	Post thigh muscles	+							+			
4	F	62	Uterus				+	+						
5	M	15	Lat neck		+		+						+	
6	M	51	Pleura	+	+	+							+	+
7	F	35±	Leg (subcutaneous)	+				+						
8	M	6	Liver		+	+						+		

(1943) patient had a tumor of the back which, during the course of 20 years, recurred locally six times and was apparently a liposarcoma showing erythroblastic activity. He suggested that it could be called a mesenchymoma. Another case which may possibly belong to this group is that of Rabson (1938) who, using the term "multiple mesenchymal hemendothelioma" described a 65-year-old man who died with multiple vascular neoplasms throughout the body.

In addition to blood vessels and primitive mesenchyme, bone and hematopoietic tissues were observed. The tumors at least demonstrated the potency of the mesenchyme to form tissues of differing types. The group of cases of extrasketal ossifying tumors collected from the literature and from the Bone Sarcoma Registry of the American College of Surgeons by Wilson (1941) probably includes some malignant mesodermal mixed tumors, but it is impossible to be sure, for the bone was such a predominant feature that the other components of the tumors were referred to only as round and spindle cells.

and their analysis not attempted Case 8 in the present group has already been reported by Donovan and Santulli (1946) The authors got the name mesenchymoma from the pathologic report of Dr Dorothy Anderson included in their paper It was suggested to Dr Anderson by the writer

The names most favored by the authors of these papers are mesenchymoma or mesenchymal or mesodermal mixed tumor Because the name mixed tumor has become so closely associated with the mixed tumors of the mucous, salivary, lacrymal and sweat glands and has also been used for other mixed tumors of the urogenital system and breast which contain epithelial structures, the writer feels that it is safer to use the word mesenchymoma to designate them This word has had some fascination for other authors who, not realizing that it had already been preempted for use in describing malignant mesenchymal mixed tumors, have applied it to other growths Thus Novak (1940) used it to describe the group of theca and granulosa cell tumors of the ovary and Tauber, Goldman and Bassett (1938) suggested it for what is probably an epithelioma of the skin

CASE HISTORIES

Case 1—N M (48362-50371), white male aged 77 years Three weeks before admission a painless swelling appeared in the right buttock On examination a deep mass measuring 10 x 7 cm was found 5/23/32 the mass was "shelled out" from its position deep to the gluteus maximus muscle and superficial to the fascia covering the pyriformis 10/7/32 a local reappearance in the operative scar was removed with some of the surrounding muscle This was ineffectual and 1/21/33 a third attempt removed a tumor 6 cm in diameter from the region of the pyriformis and other external rotator muscles and the sciatic nerve Postoperative radiotherapy did not check the persistent local extension of the tumor which continued until he died in a nursing home in September, 1934 It is unknown whether or not there were distant metastases The original tumor and the first recurrence showed areas of fibrosarcoma and liposarcoma The second recurrence showed a definite osteogenic sarcoma with areas of fibrosarcoma and probably leiomyosarcoma (Figs 1 and 2)

Case 2—W S (51071-75921), white unmarried English valet aged 45 years He was first admitted to the Presbyterian Hospital 4/17/33 with a mass in the anterior region of the right thigh which had remained the size of a walnut for 4½ years but during the preceding six months had increased rapidly until it had reached dimensions of 14 x 10 x 5 cm At operation the next day a fusiform knobby firm mass was found in the rectus femoris muscle near its junction with the tendon It was removed with some of the surrounding muscle Function was relatively good postoperatively because the crureus and vastus muscles compensated for the loss of the rectus He remained well for more than five years when he developed cough and hemoptysis Roentgenogram was suggestive of neoplastic lung involvement and he was treated with roentgenotherapy in the autumn of 1938 The disease progressed slowly and some doubt was felt about the nature of the process in the lung until 10/7/40, 7½ years after operation, when a bronchoscopic biopsy showed tumor He then went steadily downhill as the tumor spread in his lungs in spite of a small amount of roentgenotherapy He died 12/24/40, seven years and eight months after the tumor was first removed and over twelve years after its presence was first noted The original tumor showed a growth made up of juxtaposed areas of osteogenic- and chondrosarcoma, reticulum cell sarcoma, leiomyosarcoma, and an angiomatoid proliferation of capillaries The bronchus metastasis showed only the tumor reticulum cells (Figs 3, 4, and 5)



FIG 1—Case 1 Mesenchymoma of deep gluteal muscles

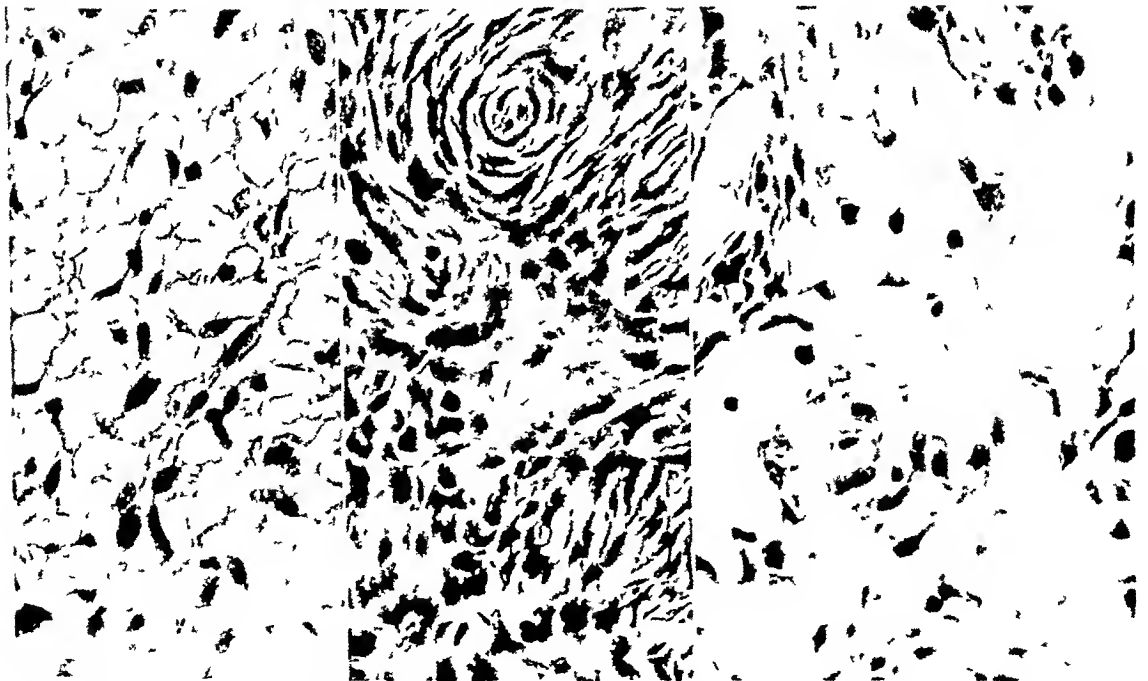


FIG 2—Case 1 Mesenchymoma of the deep gluteal tissues. At the left an area of partly differentiated liposarcoma, in the center is differentiated fibrosarcoma. These two are from the primary tumor. At the right is an area of osteogenic sarcoma from the second recurrence.

Case 3—D C (72197) A 70-year-old married Hebrew pattern grader had noted a swelling of the posterior surface of the left lower thigh 4 months before admission to the Presbyterian Hospital. It appeared shortly after he experienced a sharp pain in the left calf. When the pain stopped the tumor remained symptomless and apparently stationary in size. When examined the mass was very firm, irregular in outline, deeply



FIG 3—Case 2 Mesenchymoma of rectus femoris muscle

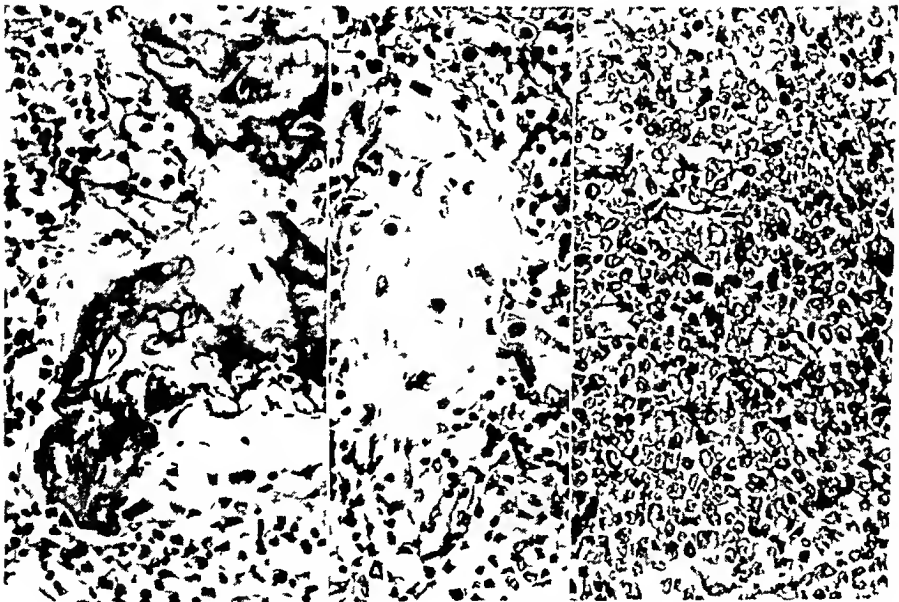


FIG 4—Case 2 Mesenchymoma of the rectus femoris muscle. At the left an area of osteogenic sarcoma, in the center chondrosarcoma and at the right reticulum cell sarcoma

attached and measured 16 x 11 cm. Roentgen examination was negative. At exploration 10/13/39 it was found that the tumor lay in the muscles and deep to them. A biopsy alone was taken. Roentgenotherapy was given through a posterior and two lateral portals. A total of 8200 r measured in air was given from 10/19/39 to 2/5/40. The factors were

MESENCHYMOMA

200 KV, 25 MA, TSD 50 cm filter 1 mm Cu and 1 25 Al The tumor failed to respond and it was suspected of extending upward into the pelvis He died at home

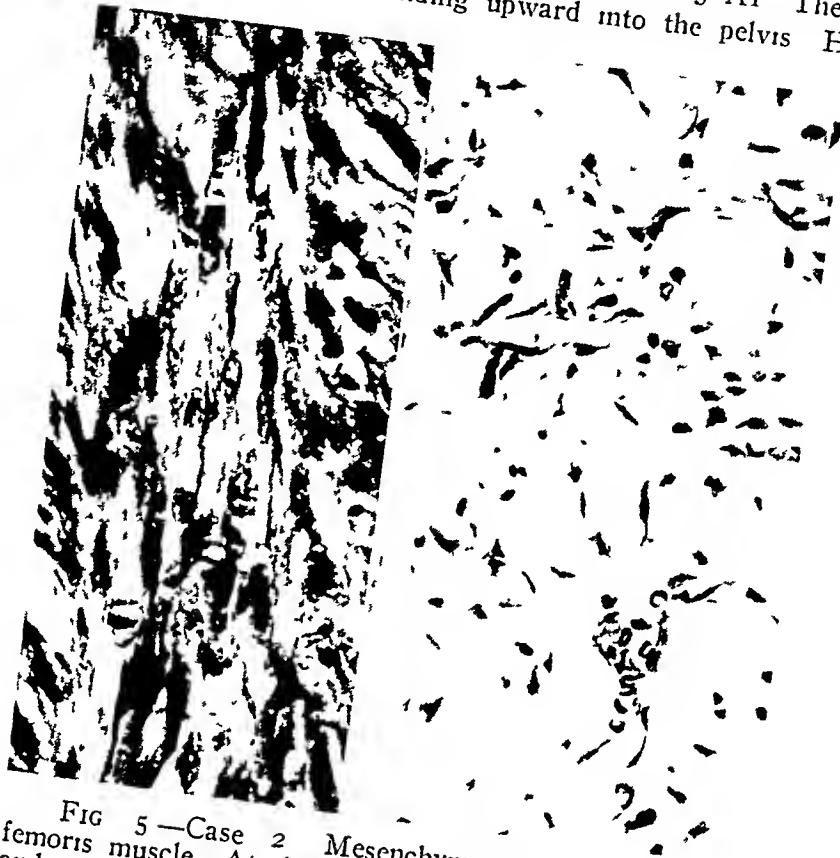


FIG 5—Case 2 Mesenchymoma of the rectus femoris muscle At the left an area of leiomyosarcoma and at the right another area showing angiomatoid proliferation of capillaries

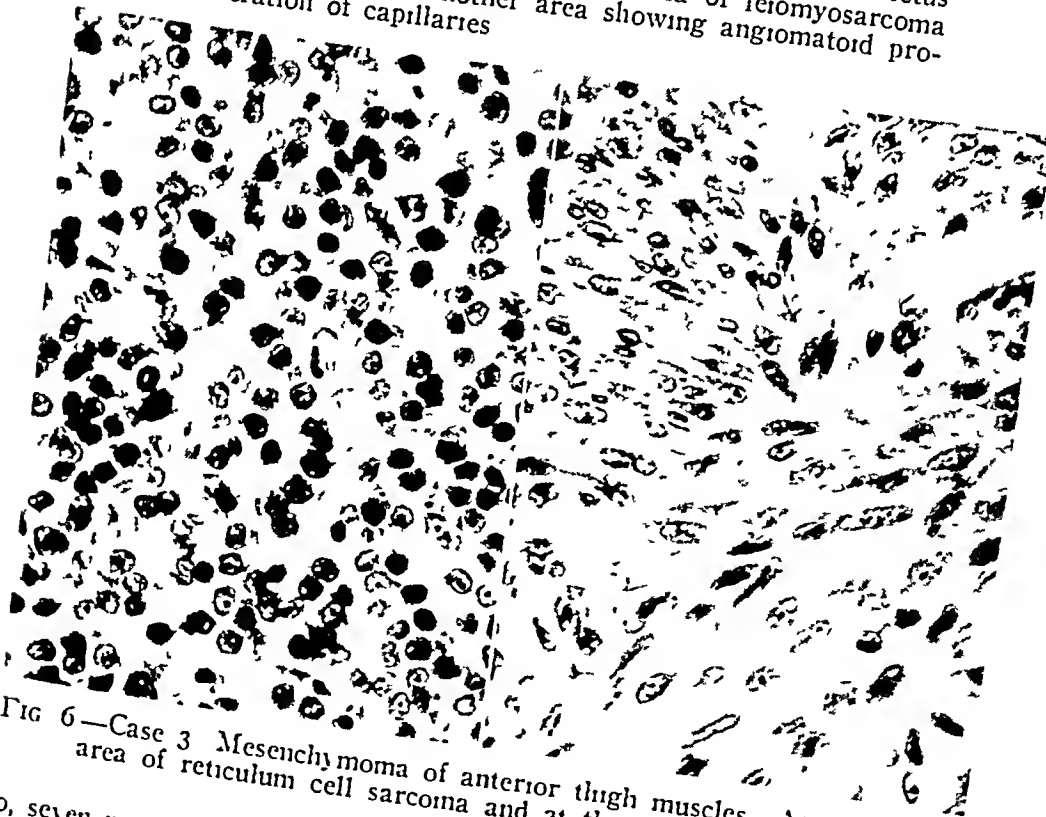


FIG 6—Case 3 Mesenchymoma of anterior thigh muscles At the left an area of reticulum cell sarcoma and at the right fibrosarcoma

5/25/40, seven months after the beginning of treatment and 11 months after the tumor was first noticed. The biopsy showed in juxtaposition two widely different tumor forms,

a fibrosarcoma and a reticulum cell sarcoma (Fig 6) (Case mentioned in Stout, A P, *Sarcomas of the Soft Parts J Missouri State Med Assoc*, 44 329-334, 1947)

Case 4—(P & S 254457), white female age 62 years She suffered for two years with backache and was treated with "ovarian hormone" During the last seven months of this period there were attacks of more and less severe vaginal bleeding and when some masses of necrotic tissue were passed a leiomyosarcoma of the uterus was suspected from histologic examination A total hysterectomy was done without removing the tubes and ovaries The uterus measured 85 x 52 x 4 cm Its cavity was dilated and filled with friable necrotic tumor which invaded the myometrium almost reaching the serosa The growth was largely leiomyosarcoma with one portion composed of rhabdomyosarcoma (Fig 7) (Courtesy of Dr A O Severance, Nix Hospital, San Antonio, Texas) This uterine case is an example of the malignant mixed tumors of the urogenital tract and therefore does not properly belong among the others It is included solely for comparison

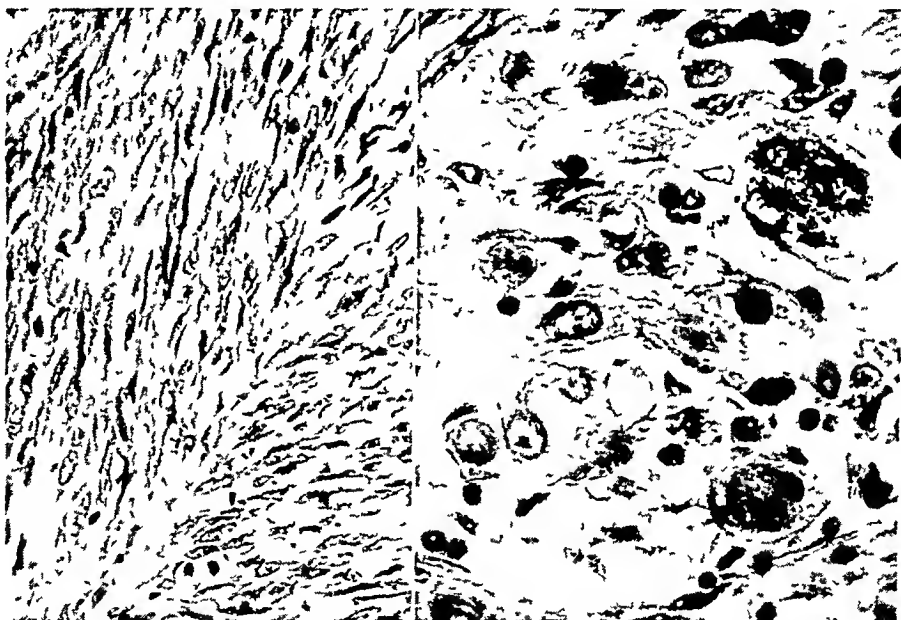


Fig 7—Case 4 Mesenchymoma of the uterus At the left leiomyosarcoma, at the right rhabdomyosarcoma

Case 5—(P & S 24674) A L A male Italian American student age 15 years Four weeks before admission a mass was noted in the right antero-lateral neck region It measured 5 x 3 x 3 cm At operation its upper end was adherent near the angle of the mandible and its lower pole was adherent at the level of the thyroid cartilage It extended from the anterior border of the sterno-mastoid muscle to within 2 cm of the midline The external carotid artery passed through it and was resected with it The operator felt that it was completely removed It varied in consistency from almost cartilaginous to fleshy A series of twenty postoperative x-ray treatments were given from 5/3/46 to 6/12/46 to the right and left sides of the neck, 2950 r to each, 9½ months after excision there was no evidence of recurrence This tumor showed areas of hemangiopericytoma, leiomyosarcoma and undifferentiated myxoid tissue (Fig 8) (Courtesy of Dr G Y McClure, Grasslands Hospital, Valhalla, N Y)

Case 6—(P & S 24830) A white male age 51 years The presence of a mass in the right lung field had been known for four years It was discovered when a roentgenogram was taken during an influenzal attack, and was thought to be a cyst When a repeat roentgenogram showed that it had doubled in size, operative removal was undertaken At

operation an encapsulated mass measuring $10.3 \times 3.5 \times 7.5$ cm was removed from the fissure between the upper right and middle lobes. The tumor was a mixture of fibrosarcoma, hemangiopericytoma, hemangioendothelioma, liposarcoma, and myxoma (Case of Alston and Paulson)

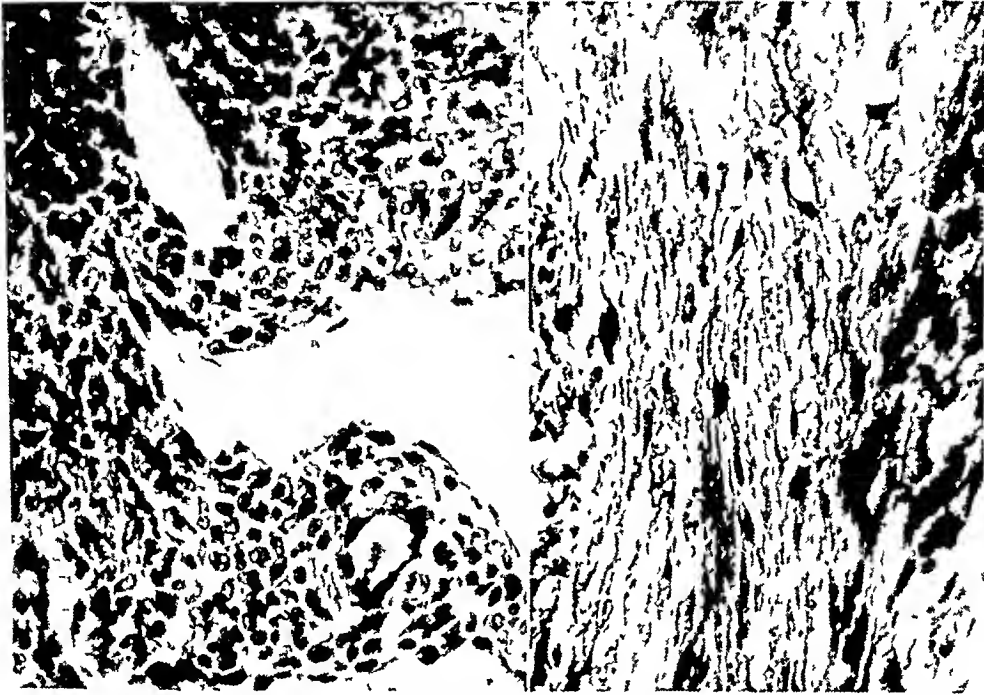


FIG 8—Case 5 Mesenchymoma of deep tissues in the lateral neck. At the left hemangiopericytoma and at the right leiomyosarcoma

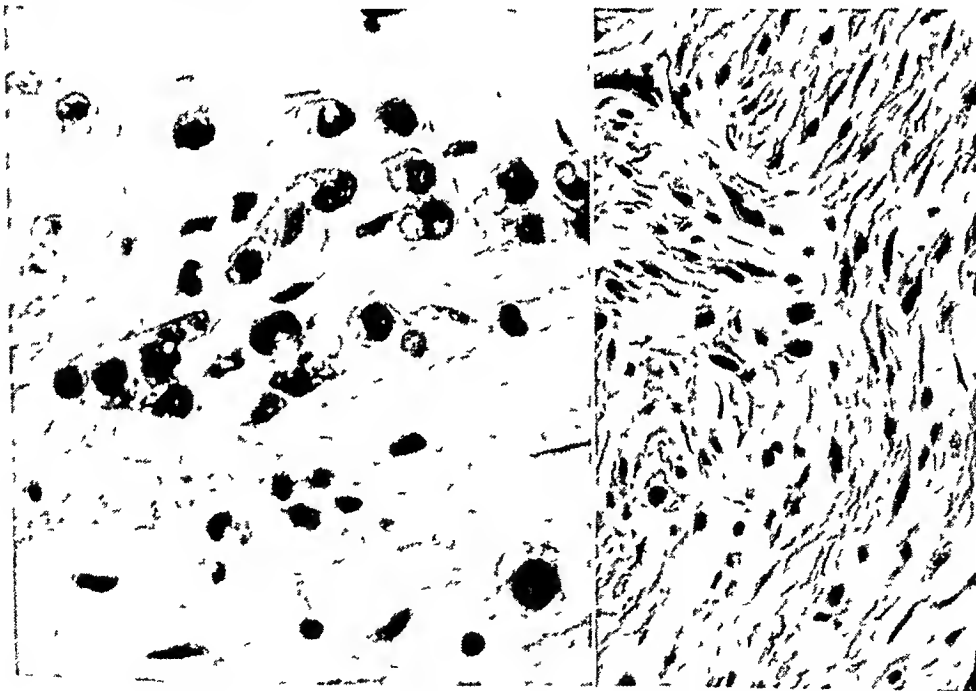


FIG 9—Case 7 Mesenchymoma of the leg. At the left rhabdomyosarcoma and at the right fibrosarcoma

Case 7—(P & S 25181) Female 35 \pm years old. An encapsulated nodule was removed from the leg "over the tibia" for cosmetic reasons. It measured approximately 14×11 mm. It was made up of a mixture of rhabdomyoblasts and fibrosarcoma (Fig 9). (Courtesy of Dr. Philip Rosenblatt, the Jewish Hospital, Brooklyn, N. Y.)

Case 8—(91982) A six-year-old white boy came to the Babies Hospital, New York, because an epigastric mass had been felt on physical examination one week before. The mass lay to the left of the midline, was continuous with the liver and measured 6 cm in diameter. Roentgen-ray showed that the stomach was compressed and displaced laterally by the mass. 12/7/44 at operation the mass replaced most of the left lobe of the liver projecting from its under surface. The left lobe was resected. There were no evidences of recurrence two years after operation. The tumor was made up of myxoid areas, angiomatous parts and tissue suggesting liposarcoma (Fig 10). (Case reported by Donovan and Santulli)

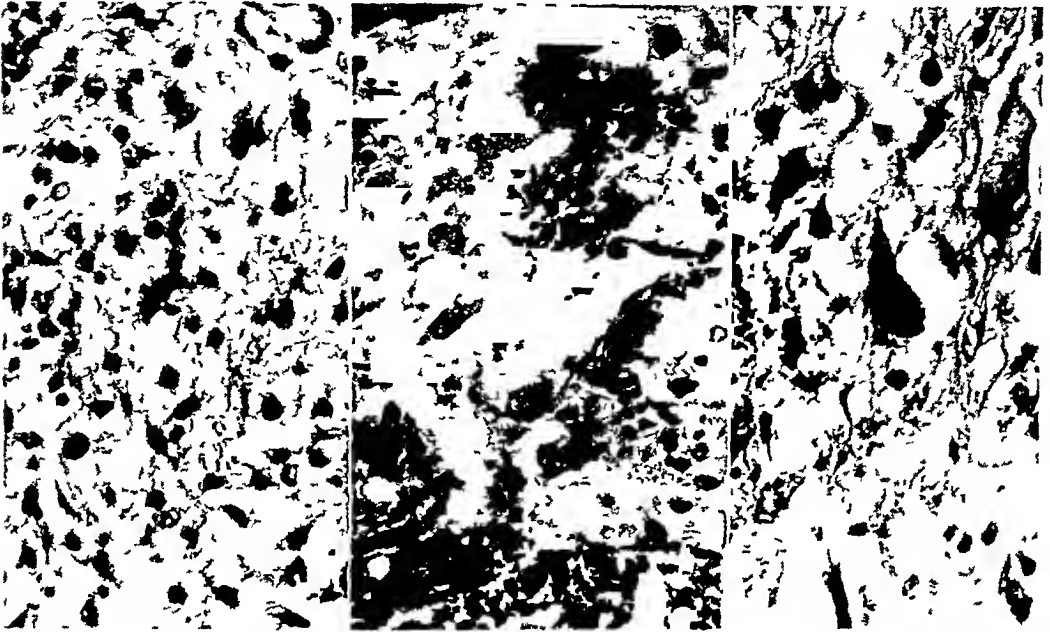


FIG 10—Case 8 Mesenchymoma of the liver. At the left myxoma, in the middle hemangioma and at the right liposarcoma.

This group of malignant mixed mesenchymal tumors is of considerable interest because it proves that such amalgamations are not always confined to certain definite regions where congenital malformations are to be expected such as the urogenital tract and breast but may be found in other organs and the soft parts. Whether or not all of them are dysontogenetic growths starting from congenitally misplaced mesenchymal cells is impossible to prove and remains a pure speculation. From whatever cells they may arise, there is some support for the belief that metaplasia plays some part in their development. There is, for example, the classical experiment of Carey (1921) who succeeded in transforming the normal smooth muscle cells of the urinary bladder into striated muscle cells by repeated emptying and filling and there are countless examples of heterotopic bone and cartilage formation due to physico-chemical changes in the environment. If such metamorphoses can occur in non-neoplastic cells, it is not difficult to suppose that it may occur in neoplasms.

It would be most reasonable perhaps to call such neoplasms mixed tumors but if that is done it requires another adjective to differentiate them from the epithelium-containing mixed tumors for which that name has long been used.

and "mesenchymal mixed tumor" seems an unnecessarily cumbersome term. The word mesenchymoma has already been applied to these tumors by some authors and this appeals to the writer as proper and pertinent. It is necessary to indicate by an adjective whether a given tumor is benign or malignant, since both varieties of the tumor are formed. The group of cases here reported are all malignant mesenchymomas.

So far as treatment is concerned, it is obvious that early and radical excision is essential even if this means amputation. The writer once again wishes to emphasize the importance of biopsy before treatment in all tumors of the soft parts. Only by learning beforehand the nature of the growth can the form of therapy offering the best hope of cure be undertaken at the outset. If the first attempt is inadequate and fails, it is seldom indeed that subsequent attempts will succeed no matter how radical they may be.

SUMMARY

A group of several unusual malignant neoplasms is reported, each one of which is composed of a mixture of malignant tumor forms derived from the mesenchyme and amalgamated into a single mass. Most of these arose in the soft parts. Such tumors belong to a group called mesenchymomas of which there are both benign and malignant forms and which are more commonly observed in the urogenital tract and breast.

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LINGUAL GOITER

REPORT OF THREE CASES

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THYROID ANOMALIES occurring in the tongue are of interest to the surgeon not only because of the practical problems involved in their surgical treatment but also because of their embryologic origin and the various parenchymatous changes to which they are subject. The favored site for the occurrence of thyroid tissue in the tongue is at its pharyngeal portion in the region of the foramen caecum. Aberrant thyroid glandular tissue rarely occurs in the body of the tongue. Tumors arising from this misplaced thyroid tissue have been described and reported under the designation of lingual thyroid, lingual goiter or thyroid tumor at the root of the tongue. These terms are often further qualified by aberrant or accessory. The term lingual thyroid is correctly used when there is a thyroid gland in the neck and when the lingual tissue functions as accessory thyroid. Lingual goiter should be applied to hypertrophic thyroid tissue at the base of the tongue in those instances of nonmigration of the thyroid anlage from the region of the foramen caecum.

In an unusually comprehensive review Montgomery^{1,2} gathered all the cases of lingual thyroid nodules reported in the literature through 1936, of which there were 231 possible cases, and of which only 144 were personally authenticated and accepted by him. Of these 144 cases there were 142 instances in which the lesion occurred on the dorsum of the tongue and only two instances in which the thyroid tissue developed in the body of the tongue. Among these lingual thyroid nodules, there was one case of his own, reported by Montgomery. The criteria of authenticity accepted by him were (1) the examination of the specimen removed which should reveal thyroid gland tissue, or in lieu of this requirement, (2) thyroid insufficiency should supervene following removal of the nodule, and, finally, (3) the lesion should appear in the substance of the tongue between the epiglottis and the circumvallate papillae.

Montgomery reported only those cases in which the lingual thyroid tumor was causing symptoms. The incidence of thyroid tissue originating in the median anlage and not producing symptoms will doubtless never be established. Montgomery's² review subsequently appeared in a monograph to which reference should be made for an analysis of case reports appearing in the literature to 1936. Shortly after this review appeared, Buckman³ published a summary of case reports to and including 1935. He included in his tabulation 242 cases including one of his own. There is a marked discrepancy in the number of cases reported by these two authors. This is probably due to the fact that the criteria of authenticity adopted by Montgomery were evidently not those of

* Presented before the New York Surgical Society, November 13, 1946

Buckman who included at least 32 cases in his series which did not meet the criteria of Montgomery ²

It seems that Hickman's⁴ case of congenital tumor of the base of the tongue, published in 1869, and authenticated by Montgomery, is the first case on record of a lingual thyroid nodule Bernays,⁵ in 1888, removed a lingual thyroid tumor substantiated by histologic examination A fairly extensive search of the literature revealed approximately 14 cases of lingual thyroid nodule for the period 1936 to 1945, inclusive Some of these case reports are unusually brief and lacking in sufficient pathologic data to be completely authentic Some possibly have escaped notice because they were published under designations other than lingual thyroids

It is the purpose of this report to review three cases of lingual goiter operated upon by the author, at the Long Island College Hospital They are added to the cases reported in the literature in the hope that they may prove of interest not only because of their symptomatology and surgical treatment but also in view of their histologic findings

CASE REPORTS

Case 1—Miss A. L., age 30, stenographer, was first seen February 2, 1933 She was admitted to the Long Island College Hospital February 4, 1933, and discharged February 18, 1933

The principal complaints included difficulty in swallowing, severe choking attacks and a change in the voice Since her childhood the patient's voice had been husky, low-pitched and "throaty" Swallowing was accomplished with increasing difficulty This caused her to "gulp" her food Frequent attacks of choking were provoked by swallowing solid foods Eating became a source of great anxiety During the past four years, there had been a gradual loss of 12 pounds in weight Two years previously, she had had a severe choking spell, caused by eating a sandwich She had become extremely nervous and because of belching and certain abdominal complaints, appendectomy was performed The choking attacks gradually became more frequent and more serious, and she had to resort to free draughts of water to aid in swallowing Four months previously, she had had an alarming attack following the eating of an apple, and this was followed three days later by another attack Shortly before her first visit, she had had a severe choking spell, unprovoked by eating For a considerable period, there had been a constant feeling of "tightness" in her throat, and during the choking attacks she suffered from severe dyspnea and palpitation She became "panicky" and at times felt that she was "passing-out"

Normal menstruation began at the age of 12 During the six months previous to her examination, the menstrual periods had become irregular, scantier, and of two days' duration Her general health had been good

The patient was an alert, well-nourished, undersized young woman, whose speech had a peculiar "throaty" quality The ocular reactions were normal, the palpebral clefts were approximately equal and there was no exophthalmos With the tongue protruded well forward a submucosal nodule approximately the size of a golf ball, was located centrally on the dorsum of the tongue posterior to the region of the foramen caecum It protruded from the surface, impinged upon the posterior pharyngeal wall and continued downward to the tip of the epiglottis, markedly compromising the pharyngeal air space With the exception of a few irregularities, the surface of the tumor was smooth It was red in color and appeared hypervascular It was impossible by laryngoscopic examination to obtain a view of the larynx which was obscured by the superimposed mass A small papilla, centrally located on the superior surface of the tumor, was noted. It was firm, elastic in consistency and measured 2 mm in diameter A diagnosis of lingual thyroid nodule was made

The general physical examination was negative. A cervical thyroid gland could not be palpated. In the midline of the neck, above the hyoid bone, a diffuse prominence suggesting pressure from the throat was seen. There was no tremor. The pulse was 82, the systolic blood pressure 110 mm Hg, and the respirations 20 per minute. Weight 112 pounds. The temperature averaged 97.8° F. The blood counts and the hemoglobin determinations were all within normal limits.

The urine was negative. The basal metabolic rates taken on two successive days were -22 per cent and -21.4 per cent, respectively. A comparison of the patient's height with that of both parents, two adult sisters and one brother revealed that she was definitely undersized and the smallest in the entire family.

Operation—February 6, 1933. Partial excision of a lingual thyroid, under ether anesthesia. Preliminary hypodermic injections of morphine were administered. The patient became drowsy and the pulse depressed, in keeping with the increased response to morphine and ether in patients with hypothyroidism as compared to those with hyperthyroidism. Ether vapor was administered through a nasal catheter. The head was placed in full hyperextension. Three sutures of braided silk were used, one was placed through the tip of the tongue and one on each side posteriorly through the entire substance of the tongue. By traction upon these sutures the tongue could be drawn out and with digital pressure the tumor could be brought well forward and satisfactorily exposed. The nodule was approximately as large as an ordinary egg and was covered by the mucous membrane of the tongue. It was oval in shape with its long diameter running anteroposteriorly. At the anterior pole a definite dimple indicating the position of the foramen caecum was recognized. The overlying mucous membrane was bright red in color and large veins were seen coursing over the lateral margins of the mass. Occasionally, the respirations became somewhat embarrassed due to pressure on the epiglottis and larynx. The difficulty was overcome by exerting digital pressure behind the tumor. Four heavy, braided, transfixion ligatures were placed transversely through the substance of the tongue below the tumor mass. The farthest posterior was placed with some difficulty immediately above the epiglottis. With good exposure obtained, a lenticular incision was made on each lateral margin of the tumor beginning well posteriorly and carried forward so that the junction of the two incisions included the foramen caecum. A margin of mucous membrane, three-quarters of a centimeter in width, was allowed to remain attached to the lateral borders of the tumor. Immediately under the mucous membrane of the tongue, the surface of the tumor was exposed. It appeared to be glandular tissue of pink color and cellular appearance. The tumor was clearly defined from the normal lingual musculature of the tongue and had a limiting membrane or pseudocapsule. A generous wedge of tissue was removed by cutting downward slightly beyond the midportion of the tongue. In order to avoid complete excision margins of glandular tissue on the lateral aspects were allowed to remain. Hemorrhage was not extensive. The heavy transfixion sutures, previously placed through the tongue and beneath the tumor, were then snugly tied. Additional approximating sutures of chromic catgut were used. The transfixion sutures were left long for purposes of traction in case of emergency. The tongue now appeared somewhat edematous but there was no serious respiratory embarrassment.

Immediate inspection of the specimen showed that it included the foramen caecum. The parenchyma of the tumor resembled that frequently seen in a partially degenerated adenoma of the "fetal" type. It had a glistening, relatively homogeneous, pale-yellowish appearance and contained a moderate amount of colloid. Toward the anterior pole of the specimen, there was an area of degeneration. Specimens of the tumor were placed in formalin.

Postoperative Course—Recovery was uneventful. The rectal temperature was 101.8° F and the pulse 122 on the evening of the day of operation. Five days after operation, under light anesthesia, the silk transfixion sutures were removed. The patient was discharged 12 days after operation, with normal temperature, pulse and respirations. The basal metabolic rate on February 16th was -32.9 per cent.

Gross Pathology—The specimen of a lingual thyroid tumor weighed eight Gm, and

measured $2.5 \times 3 \times 3$ cm. The superior surface was covered by mucous membrane and presented a slightly lobular, irregular surface. On the superior surface, eccentrically placed, there was a minute depression which probably represented the site of the foramen caecum. On the inferior border of the specimen, some reddened, hemorrhagic muscle fibers were seen. The cut-surface of the tumor proper presented a lobular appearance, a pinkish-yellow color and a smooth homogeneous structure grossly resembling the appearance of a fetal adenoma. A moderate amount of stroma was present and in one area the tissue resembled the appearance of normal thyroid gland.

Microscopic Examination—The superior surface of the section was covered by normal stratified squamous epithelium characteristic of the lingual mucosa. Toward the anterior extremity of the specimen a blind tract was seen leading downward a considerable distance below the surface. This tract represented the foramen caecum and the rudimentary thyroglossal duct (Figs 1 and 2). Below the lingual mucosa there was a wide zone of hyalinized fibrous tissue, which anteriorly contained groups of epithelial cells, some of which were seen to form small and large colloid-containing follicles characteristic of normal thyroid tissue. The acini were of irregular size, without definite architecture, and were lined by cuboidal or low columnar cells, the nuclei of which were deeply stained. A pink-staining colloid filled the follicles.

In the fibrous zone adjoining the capsules of the several nodules composing the tumor proper, lamellated layers of thyroid follicles fairly normal in appearance were seen. Immediately under the capsules there was a distinct difference in the type of tissue composing the nodules. It very closely resembled that frequently seen in fetal adenoma (Fig 3). The bulk of the nodules was composed of large numbers of small and medium sized follicles simulating the appearance of normal thyroid but without definite architectural arrangement (Fig 4). Toward the center of the tumor there was an area of degeneration in which the follicles were quite irregular in shape and varied greatly in size. They were separated by a fibrous and myxomatous ground substance, such as is often seen in adenomatous goiter (Fig 5). In the center of the largest nodule composing the tumor there was an area of fibrosis, necrosis and hemorrhage.

In the area of greatest depth of the tumor the thyroid tissue appeared as solid groups or cords of cells and as large numbers of very minute follicles with a sparse intervening stroma. This tissue presented no definite architecture. The nuclei were deep-staining and hyperchromatic. The parenchyma presented the appearance characteristic of the cellular fetal adenoma (Fig 6).

The deeper portions of the rudimentary thyroglossal duct were lined by transitional epithelium possessing a ciliated border (Fig 7). In the fibrous tissue surrounding the duct there was a considerable infiltration of lymphoid cells. *Pathologic Diagnosis* Lingual goiter of the fetal adenomatous type.

Progress Notes—March 6, 1933. Since her discharge from the hospital February 18th, the patient had been taking thyroid extract one grain twice daily. She was conscious of some tightness in her throat. The voice was clear, and a slight Chvostek sign was noted on the left side. The pulse was 92. There was no tremor. Her weight was 106 pounds. The basal metabolic rate was -15 per cent. Two thyroactin tablets, containing one-half grain of thyroid extract each, were prescribed daily.

March 27, 1933. A small, rounded elevation was noted at the site of the original tumor, and the operative incision had almost entirely healed. The pulse was 90, and the weight 107 pounds.

April 10, 1933. The patient had been taking one-half grain thyroactin tablets twice daily for the previous 35 days. As a result, she became more energetic and alert, and felt generally improved. The voice was clear, she swallowed with ease and stated that she had lost the taste of sweet but not of sour articles. There was a slight increase in the pulse rate to 96 beats per minute. Her weight was 106.5 pounds, and the basal metabolic rate had increased from -15 per cent to +7.4 per cent. During the following two months, the therapy was reduced to one-half grain of thyroid extract per day. Because of some nervousness it

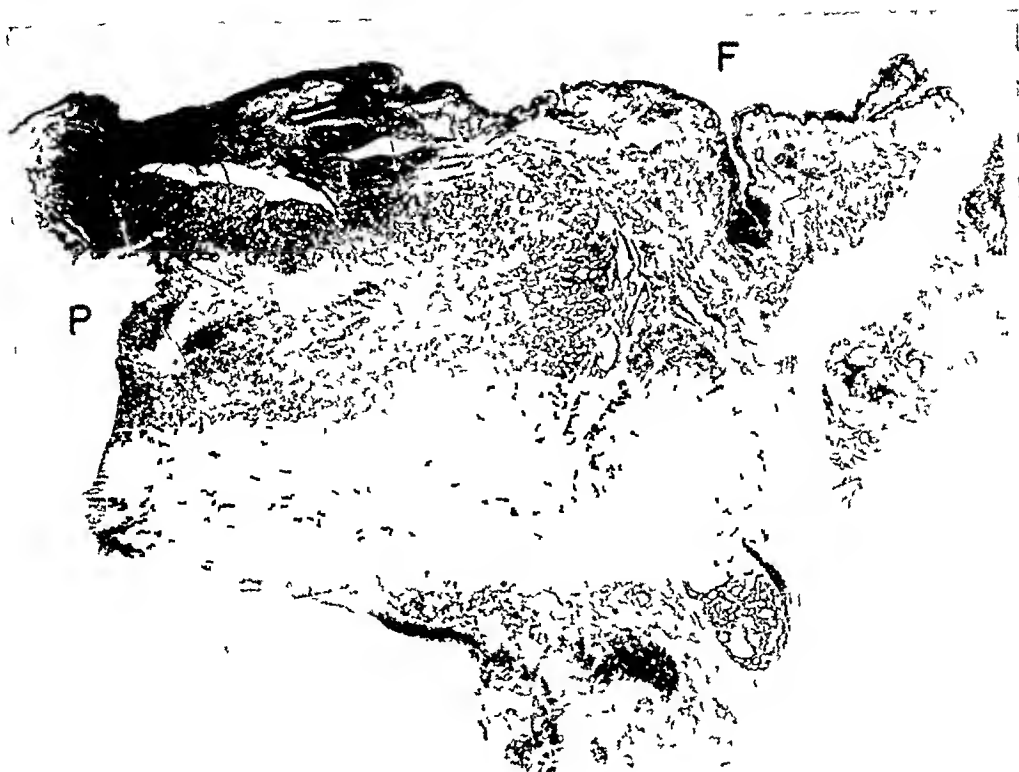


FIG 1—Case 1 Photomicrograph of a sagittal section through the entire specimen of a lingual goiter from a woman 30 years of age. Note anteriorly the foramen caecum (F) and the rudimentary thyroglossal duct. Note the encapsulated nodules which showed multiple types of parenchymatous overgrowth and the large area of myxomatous degeneration in the center of the largest nodule. The posterior pole (P) was transected and allowed to remain *in situ* ($\times 45$)



FIG 2—Case 1 Greater magnification, photomicrograph of an area of section shown in Figure 1. Note the irregularly-scattered thyroid follicles in the submucous fibrous zone and the various types of parenchymatous proliferation in the encapsulated nodules composing the lingual tumor ($\times 9$)

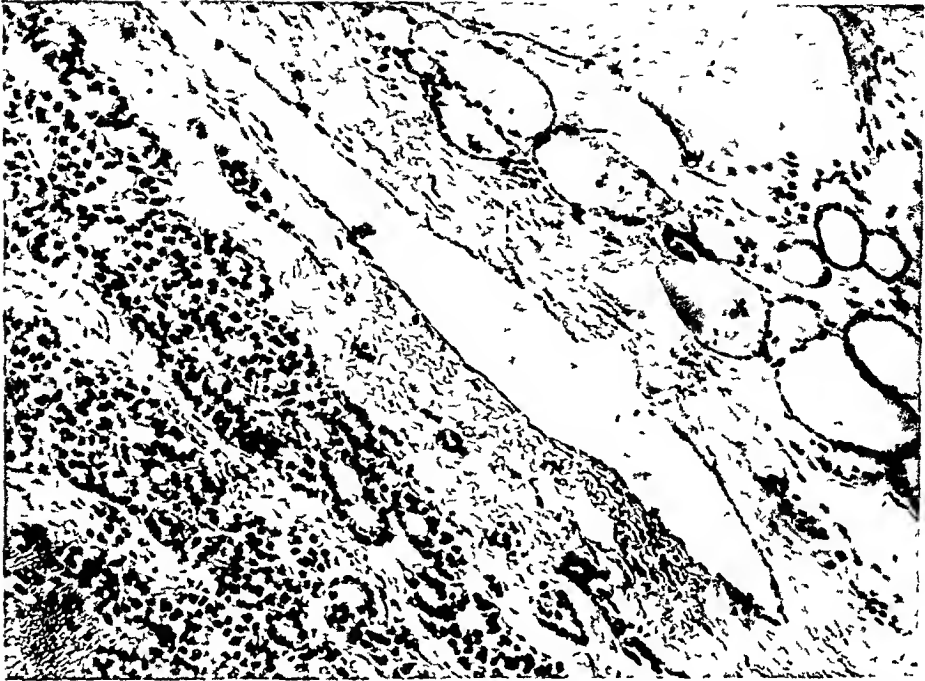


FIG 3—Case 1 Photomicrograph of normal-appearing thyroid follicles in the fibrous stroma adjoining the capsule of the lingual nodule. Below the capsule one sees a sudden transition to the fetal type of thyroid, often seen in adenoma of the cervical thyroid gland ($\times 125$)

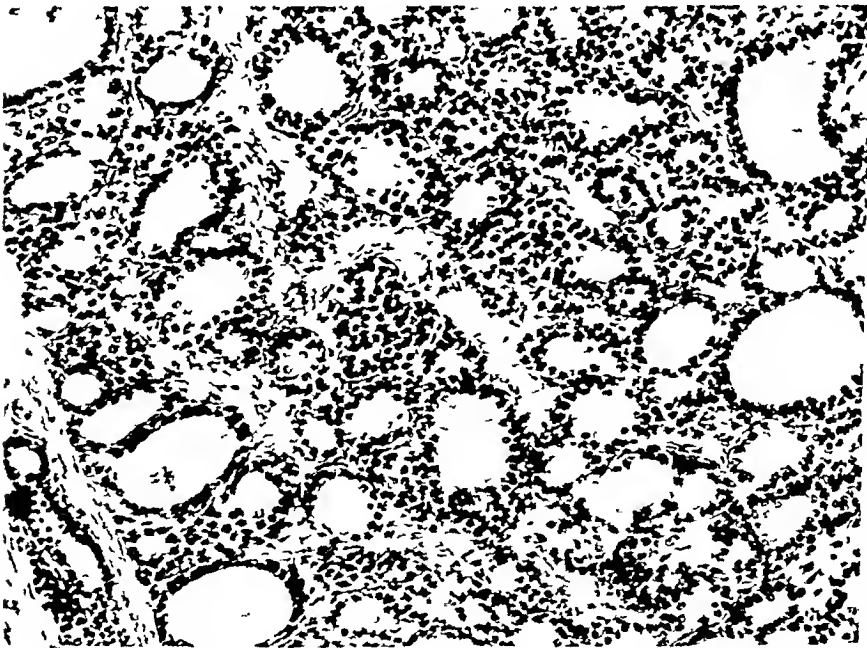


FIG 4—Case 1 Photomicrograph illustrating a fairly normal type of thyroid parenchyma found in the lingual nodule. The follicles vary greatly in size, the epithelial cells are cuboidal and the nuclei are rich in chromatin. Note the lack of definite architectural arrangement ($\times 125$)

LINGUAL GOITER

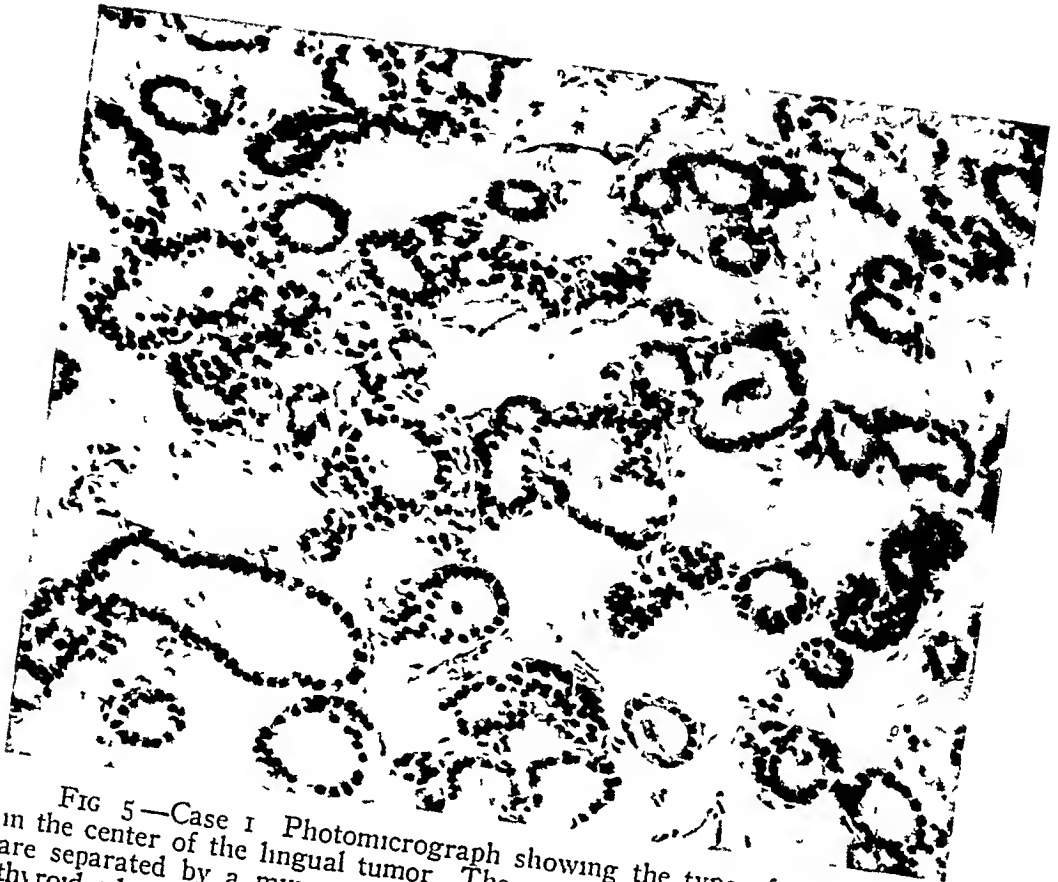


FIG 5—Case 1 Photomicrograph showing the type of tissue found in the center of the lingual tumor. The acini of irregular shape and size are separated by a myxomatous stroma characteristic of many cervical thyroid adenomas. This area bordered on a zone of necrosis and hemorrhage ($\times 125$)

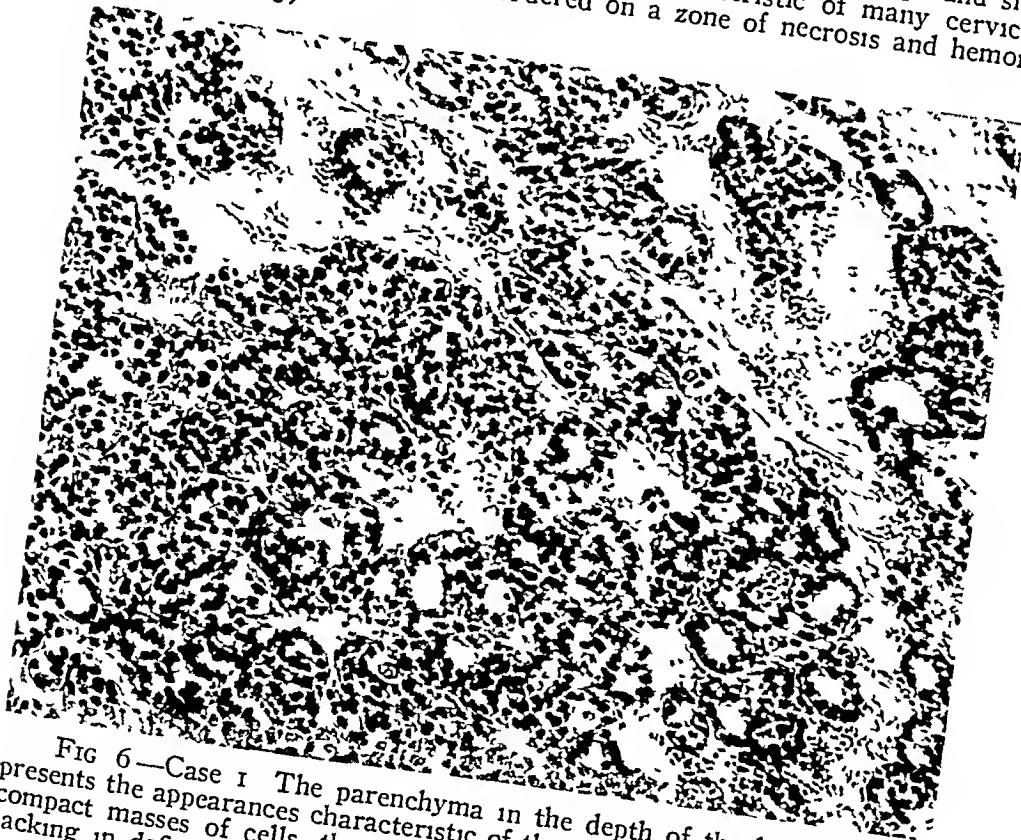


FIG 6—Case 1 The parenchyma in the depth of the lingual tumor presents the appearances characteristic of the cellular fetal adenoma. The compact masses of cells, the cellular cords and the minute follicles are lacking in definite architecture ($\times 125$)

was further reduced to one-half grain of thyroid extract twice a week. One month later, on July 8, 1933, the basal metabolic rate had fallen to -25.8 per cent. Therapy with thyroid extract was increased to one-half grain on alternating days, for 14 weeks, after which, on October 19th, the patient was again examined. She was greatly improved. The clinical symptoms of hypothyroidism had disappeared. She was instructed to continue her previous medication. After three months on this regimen, on October 12, 1933, the basal metabolic rate was -31.6 per cent. Two months later (December 20, 1933) the rate was -13.7 per cent. Thyroid extract in doses of gr 1 to gr 1.5 daily was prescribed. The basal metabolic rate two years later, on December 19, 1935, was -5.6 per cent.

Revisit—April 18, 1936. During the previous three years, the patient had been given thyroid therapy as indicated, and had felt rather well. There were no signs of hypothyroidism. The throat appeared normal. The menses had been normal. The weight was 110.5 pounds. Thyroid extract gr 1, and iodostarine gr 5 daily were prescribed.



FIG 7—Case 1. Photomicrograph showing the ciliated border of the transitional epithelium lining the rudimentary thyroglossal duct ($\times 600$)

Revisit—March 13, 1946. The basal metabolic rates taken on seven occasions, between February, 1940, and March, 1945, varied between -13.7 per cent and +10 per cent with an average of -8.2 per cent. During the previous several years, her health had been good. She continued her occupation as a secretary until January, 1946, and then had felt unable to continue. She had occasional periods of nervousness with a feeling of tightness of the throat. She had married in March, 1937, four years after her operation. She became pregnant in January, 1940. The pregnancy was normal, but the fetus, due to complications of the cord, died during the eighth month. The menopause commenced in 1941, when the patient was 39 years of age. Thyroid medication had been continued in the dosage of gr 1 and gr 1.5, on alternating days during the preceding ten years with the result that she had continued to feel well. The basal metabolic rates had varied during this time but were constantly slightly below zero, between -2 and -10 per cent, but never reached the low of -17 and -20 per cent previously mentioned. There had been no signs of hypothyroidism. Her weight was 117.5 pounds, which represented a gain of seven pounds since her visit in 1936. The throat was clear and there were no irregularities posteriorly on the dorsum of the tongue. A slightly positive Chvostek sign was elicited on the left.

During her pregnancy she had experienced extreme numbness and pain in the hands, with lack of strength in the fingers. The feeling of tightness in the throat, a mildly positive Chvostek sign and poor dentition with gum recession appeared to point to a very mild hypoparathyroidism, and a chemical examination of the blood revealed in milligrams per 100 cc of blood: Cholesterol 320, cholesterol esters 188, calcium 10.2, phosphorus 2.8, phosphatase 1.8. The basal metabolic rate was -14 per cent. She had had no iodine medication during the past several years. Medication with thyroid extract gr. 1 alternating with gr. 1.5 daily was advised together with dicalcium phosphate and calcium gluconate with vitamin D.

COMMENT—It would be correct to designate the lingual thyroid nodule in this instance as a lingual goiter, for on gross and microscopic examination it was found to have the structure, not of normal thyroid gland but of that commonly seen in adenomatous goiter involving the cervical thyroid. There was the tendency to the formation of nodules with pseudocapsules in which there was a scattering of small acini. This might be interpreted as invasion. The parenchymatous overgrowth showed a multiplicity of histologic pictures. There were areas of normal-appearing thyroid adjoining large areas of cellular hyperplasia of the fetal pattern. With and without the formation of minute acini and without definite architectural arrangement, these findings add to the difficulties of pathologic diagnosis.

The nodule must have been present since childhood, for in the early years the voice had been husky, swallowing was difficult and there had been frequent choking attacks. There was evidently an associated hypothyroidism, for the patient was under-sized and, finally, when she presented herself at the age of 30, her metabolic rate registered -22.5 per cent. A cervical thyroid was not palpable. The lingual thyroid was doubtless the only thyroid tissue the patient possessed because after partial excision of the tumor, a moderately severe hypothyroidism intervened. It could hardly be called myxedema. Therapy with thyroid extract in dosage of gr. 1 twice daily was instituted immediately following operation. After a brief interval symptoms of a mild hypothyroidism followed. The basal metabolic rate over the years had risen from the preoperative level of -22.5 per cent to +7.4 per cent. The maintenance dosage of thyroid extract was finally found to be gr. 1 to gr. 1.5 daily. On this regimen her health was well-maintained for the past ten years or more. The basal metabolic rates, determined annually during this period, averaged -6.0 per cent. The patient was married in March, 1937, and became pregnant three years later. It would appear that ovarian function had not been disturbed by the long period of hypothyroidism from which the patient had suffered.

Case 2—I. C., a female child, age 12, was admitted to the Long Island College Hospital September 19, 1925, and discharged October 23, 1925. The chief complaints were slowness of speech and the presence of a tumor mass on the posterior dorsum of the tongue. The family history was negative for thyroid or other endocrine disorders, and the patient's general health had been good. She began to walk and talk at the average age and did well at school. Menses had not begun.

One month before the patient was admitted her father had had his attention drawn to a peculiarity in the child's speech which sounded as though she "had something" in her mouth. Upon examination of the child's throat he noted a swelling at the base of the tongue.

During the month preceding the child's admission the swelling apparently had increased in size and the impediment in speech had become more noticeable. There were no subjective symptoms such as pain or unusual difficulty in swallowing.

The patient was a well-nourished girl with a somewhat apathetic expression. She did not appear precocious, responded fairly readily and was evidently attaining puberty as evidenced by the appearance of axillary and pubic hair and by the normal development of the breasts. She did not present appearances of any endocrine disorder.

Upon examination of the throat, with the tongue well protruded, a mass was revealed in the region of the foramen caecum. The tumor occluded the space between the anterior



FIG 8—Case 2 Photomicrograph showing the surface mucosa and the submucous zone of lymphoid tissue overlying the lingual goiter from a girl 12 years of age. Her principal complaint was an impediment in speech ($\times 85$)

tonsillar pillars and the soft palate. Anteriorly it extended to the centrally located circumvallate papillae and its base was almost equal to the width of the tongue itself. The tumor was elevated from one-half to one centimeter above the surface of the tongue and was relatively smooth and dark-red in color. It appeared to be highly vascular, as indicated by many dilated veins on its surface. The tracheal rings and the cricoid and thyroid cartilages were readily palpated. A cervical thyroid gland could not be palpated. The abdomen was prominent, but otherwise negative. The temperature was 99.6°F , pulse 96, and respirations 21. Blood pressure 95/55. Blood and urine examinations revealed nothing noteworthy.

The impression gained was that we were dealing with an aberrant lingual thyroid nodule and the absence of a cervical thyroid

Biopsy of Lingual Tumor—September 21, 1925 Under ether anesthesia, the tumor at the base of the tongue was brought well into view by digital pressure deep in the pharynx Deep transfixion ligatures of medium size were placed around and below the midportion of the tumor, thus, circumscribing the area from which the biopsy was to be taken With each puncture of the needle, there was some brisk bleeding, controlled by simple pressure Incision was made over the dome of the tumor, which was covered by a thin layer of mucous membrane and apparently some fibers of the intrinsic muscles of the tongue After incision through the outer zone of the tumor a cellular, glandular-appearing structure was encountered A section was removed for microscopic study Ligation of the transfixion ligatures, previously placed, controlled all bleeding

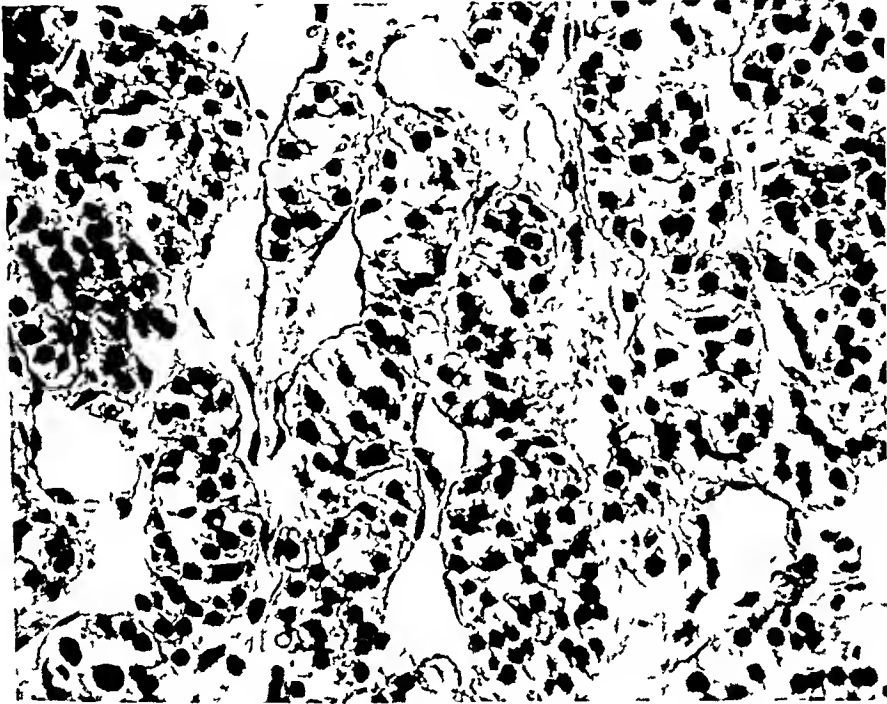


FIG 9—Case 2 Photomicrograph of a section from the biopsy specimen of lingual goiter Note the epithelial cords separated by large sinusoidal spaces and without acinar formation, a picture not uncommonly found in fetal adenoma of the cervical thyroid. ($\times 300$)

Microscopic Examination—The biopsy showed a thick surface layer of stratified squamous epithelium characteristic of the lingual mucous membrane Immediately below the mucosa, there was a broad zone in which there was an abundance of lymphoid tissue in diffusely scattered areas and containing several unusually large lymphoid follicles (Fig 8)

The tumor proper showed two types of epithelial structures In part, the tissue was composed of irregular, oval, and elongated groups and cords of cells separated from each other by minute connective tissue septa containing blood capillaries There was no attempt at the formation of follicles and nowhere was colloid to be seen The cells were fairly large They showed finely granular cytoplasm with centrally placed large, rounded and oval nuclei, which were deeply stained and rather rich in finely granular chromatin

The second type of tissue was characterized by irregular groups and cords of cells which were separated by rather large endothelial-lined sinusoidal spaces containing a few red corpuscles There was a minimum of connective tissue lining the cords and containing numbers of small blood vessels These cellular cords were composed of irregularly placed, clear cells, with vacuolated, spongy appearing cytoplasm The nuclei varied greatly in

size Some were strikingly large, rounded or oval, and rich in chromatin (Fig 9) *Pathologic Diagnosis* Lingual thyroid tumor

Recovery from the anesthesia and the operation was prompt There was a postoperative febrile reaction accompanied by swelling of the submaxillary nodes due to infection of the operative area A low grade fever continued for one week, followed by some necrosis and sloughing of tissue at the operative site Two weeks after the biopsy operation, the infection and edema of the tongue and submaxillary nodes were definitely subsiding The general condition of the patient was good There was no dysphagia but the impediment in the voice was more marked The sutures were extruded spontaneously

Partial Excision of a Lingual Thyroid Tumor—October 16, 1925 The patient was anesthetized with ether vapor The jaws were held well apart by means of a mouth gag and the tongue was drawn well forward by means of traction upon a heavy silk ligature

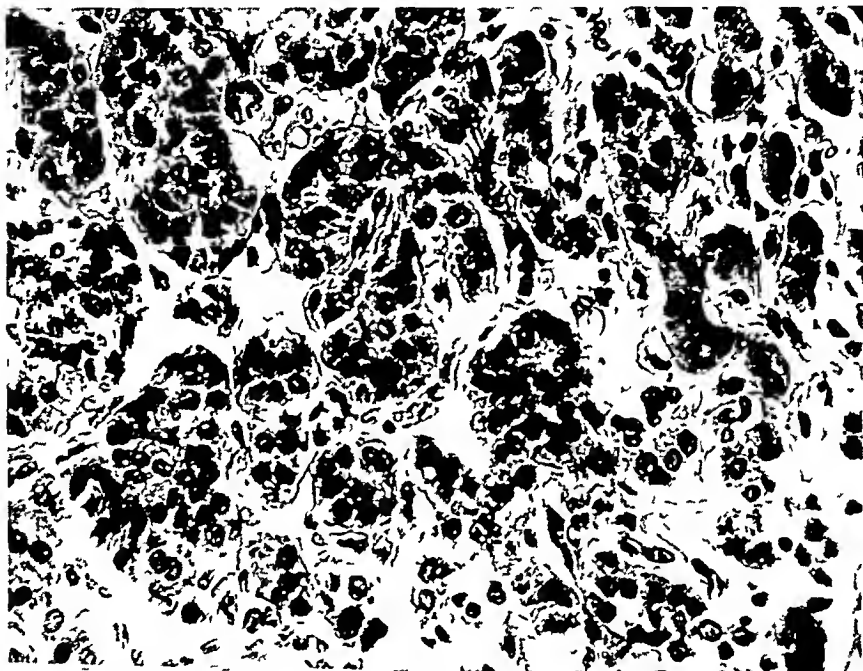


FIG 10—Case 2 Photomicrograph showing the principal type of tissue of which the body of the lingual goiter was composed There is no tendency to the formation of follicles ($\times 300$)

through the tip of the tongue A satisfactory approach to the tumor was thus obtained The separation of a large piece of necrotic tumor tissue was followed by moderate bleeding By means of digital pressure the tumor was brought well into view It had a sessile base which was constricted by means of a circumferential suture placed as low as possible, whereupon, the large superior bulging portion was removed This was followed by a moderate amount of bleeding, which was controlled by long, transfixion ligatures the ends of which were brought out of the mouth The pharynx was then explored and it was found that the tumor extended posteriorly almost to the epiglottis and appeared to extend downward into the right superior portion of the anterior cervical triangle It seemed that a more extensive removal of the tumor could only be accomplished by an external approach in the submandibular region The excised tissue which was firm, cellular and vascular, was composed of masses of parenchyma, resembling adenomatous thyroid A considerable residue of tumor necessarily remained *in situ* The specimen was placed in formalin

Pathologic Examination—Gross The specimen represented a portion of the tumor removed from the base of the tongue It measured 4 cm in long diameter and 1.5 cm in

width. No capsule was evident and the tumor obviously had not been entirely removed. The superior surface of the specimen was covered by an irregular mucous membrane with soft, nodular elevations. Upon section, the central portion of the specimen was soft, semi-translucent and glistening and resembled myxomatous tissue. In some portions of the tumor, small bundles of muscle fibers were seen. A scant amount of connective tissue stroma was present.

Microscopically, sections of the tumor presented essentially the same structure as the biopsy. There were two main types of glandular epithelium. The first composing the bulk of the specimen, was characterized by large groups of cells and cords separated from each other by minute strands of connective tissue and narrow spaces lined by endothelium. The protoplasm of the cells was abundant, homogeneous, finely granular and pink-staining. The nuclei were large, round or oval, rich in chromatin and, in general, centrally placed in the cells. There was no definite tendency to the formation of colloid containing alveoli (Fig 10).

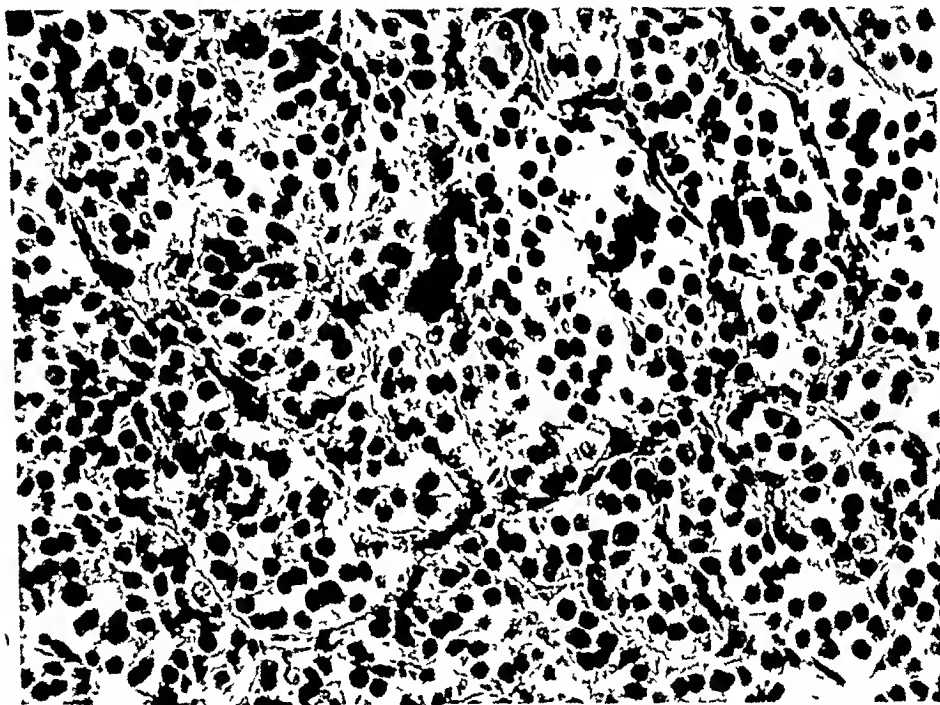


FIG 11—Case 2. Photomicrograph showing another type of epithelial growth occurring in large areas of the lingual nodule. Note the resemblance to the structure of parathyroid gland. The preliminary diagnosis of parathyroid tumor was in error ($\times 300$).

The second principal type of glandular epithelium composing the tumor resembled in many respects the structure of parathyroid gland (Fig 11). The tissue was compact and composed of irregular groups of cells and elongated cellular cords separated from each other by a minimum of stroma and slit-like endothelial spaces. The cytoplasm of the cells was fairly clear, finely granular, nonvacuolated, and the nuclei were large, centrally placed, rich in chromatin and dark-staining. There was no tendency to acinar formation and colloid was not visible. These epithelial areas were circumscribed by wide zones of dense fibrous tissue in which were seen islands and cords of epithelial cells without definite organization.

The superior portion of the tumor showed a large, thick, superficial zone of granulation tissue containing extravasated blood and large numbers of polymorphonuclear leukocytes. This superficial zone of infection resulting from the biopsy extended downward into the deeper portions of the tumor, and finally ended in a wide zone of dense fibrous tissue which circumscribed the glandular portions of the tumor proper.

A section of the biopsy tissue, fixed in an osmic acid preparation and stained with acid fuchsin and methyl green, showed numbers of small follicles and some fairly large ones.

containing a green-staining homogeneous, vacuolated colloid. The follicular cells were low columnar in type and contained a scant amount of cytoplasm in which could be seen an abundance of red-staining mitochondria. The nuclei were pale, rather large, and situated centrally in the cells. The larger colloid follicles showed a fair amount of papillary infolding of the walls. The size of the cells, the papillary infolding of the walls and the occurrence of numerous mitochondria were indications of hyperplasia and hyperfunction of these areas of glandular epithelium. Aside from a limited number of colloid vesicles, the bulk of the section was composed of groups of large epithelial cells without follicular formation. They represented compact areas of parenchyma composed of groups of cells separated from one another by minute septa of connective tissue.

Sections of the tumor were submitted to Dr. James Ewing who expressed the opinion that the tumor was of embryonal parathyroid type. On the other hand, after further study, it seemed more likely that we were dealing with atypical fetal thyroid gland.

Postoperatively, the patient had a moderate amount of discomfort. Swallowing soon became normal. The convalescence was uneventful, and the patient was discharged October 23, 1925, one week after operation at which time one transfixion suture was still *in situ*.

Follow-up The child returned for examination five weeks after operation, when the single remaining transfixion suture was removed from the tongue. Her speech was distinct and definitely improved. At the base of the tongue a small mass of tumor of firm consistency could be felt. The area of operation had healed and the patient was in good condition. Further "follow-up" examinations unfortunately were not possible.

COMMENT The lingual thyroid nodule in the case of this young girl had produced an impediment in her speech. She seemed somewhat apathetic and was probably not as alert as a normal child of her age. The tumor was fairly large and extended from the dorsum of the tongue downward into the submandibular area. The nature of the tumor was not clear. The pathologic examination of a biopsy specimen and of the tissue removed by partial excision of the tumor revealed a structure in many respects resembling parathyroid tissue. Dr. James Ewing expressed himself as favoring this diagnosis. However, after further careful studies it seemed more likely that we were dealing with an atypical fetal thyroid gland, in fact with a so-called fetal adenomatous goiter, as frequently seen in the cervical thyroid. Such fetal types of adenoma often resemble the parathyroid in structure. If this case had been one of parathyroid origin it would seem to be the second case in the literature, the first having been reported by Asch.⁶ In Asch's case tetany followed complete excision of the lingual thyroid. The post-operative course in the case just described did not afford support for or against the likelihood of the tumor being of parathyroid nature. In the first place, the excision was only partial and secondly, even though the two superior parathyroids have in a few instances been described in relation to lingual goiter the inferior parathyroids, it seems, are found in their normal cervical position and for this reason radical removal of the tumor would probably not be followed by tetany. A late "follow-up" was not possible, but five weeks after partial removal there were no evidences of tetany or hypothyroidism.

Case 3—M. G. L., a school girl (Fig 12), eight years of age, was first seen June 19, 1945, because of a tumor on the dorsum of the tongue. The patient was admitted to the Long Island College Hospital, October 29, 1945, and discharged November 8, 1945, after 11 days of hospitalization.

LINGUAL GOITER

The patient's general health had been good. Tonsillectomy had been performed at the age of two. At this time the nodule on the dorsum of the tongue was not visualized. In fact it was not recognized until about two months before her present examination when, during a routine physical examination by a pediatrician, an oval mass was noted at the base of the tongue. After the lapse of a month, there had been no change in the size of the tumor. One morning, two weeks later, a spot of blood was noted on the patient's pillow. The mother became alarmed and took the child to a local hospital where the nature of the mass was not recognized, but the possibility of "thyroglossal cyst" was mentioned. The child characteristically consumed an unusually long time in mastication and deglutition and not infrequently would spend one hour to an hour and a half over a small meal. She was disinclined to swallow or talk, and her voice had a somewhat nasal quality. The appetite was poor. She was undersized for her age and seemed not to be developing normally.

The patient was well-nourished but appeared undersized. There was some pallor of the skin which was of fine, thin texture. She was bright and alert, somewhat shy and slow in speech but she had done well in school. The eyes and ocular reactions were normal. The gums and dentition were in good condition. On the dorsum of the tongue, corresponding to the position of the foramen caecum, there was a sessile, rounded nodule, 2 cm in diameter and approximated the size of a large olive. It was fairly smooth, somewhat reddened and showed several dilated, superficial blood vessels. The tumor was moderately firm and elastic. The voice was clear and there was no unusual difficulty in swallowing at the time of the examination. Her speech had a slightly nasal quality and there was a definite gulping effort when she swallowed. She masticated thoroughly and ate slowly. The heart sounds were regular in rate and rhythm. She had a noticeably protuberant abdomen. Her weight was 53 pounds and she measured 114 cm in height. A cervical thyroid was not palpable. By indirect laryngoscopy, no evidence of laryngeal obstruction was found. The temperature was normal. The pulse averaged 85, the respirations were 22 and the systolic blood pressure was 100 mm Hg. The basal metabolic rate was +14 per cent. Chemical examination of the blood showed urea nitrogen 17.2 per cent, urea 36.8 per cent and cholesterol 271 mg per 100 cc.

Operation—Excision of lingual thyroid—October 31, 1945. A preliminary hypodermic injection of codeine sulphate gr 0.5 was administered. Light anesthesia was begun with chloroform, followed by ether delivered by nasal catheters. The patient was placed in a moderate Trendelenburg position with the head retracted. The jaws were spread well apart by means of a mouth gag. A stout ligature was placed through the tip of the tongue for purposes of retraction. Additional ligatures were placed in series of three through the lateral margins of the tongue. By means of traction upon these sutures, the tongue could be brought well forward, whereupon a satisfactory view of the tumor was obtained. Beginning in the region of the foramen caecum and extending backwards to the tip of the epiglottis,



FIG 12 — Case 3. Photograph of a child, eight years of age, who presented a lingual goiter, which caused dysphagia, hesitancy of speech and a nasal quality of the voice. She was undersized, due, it appeared, to an associated mild hypothyroidism. Note the protuberant abdomen.

an elevated bulging tumor the size of a large olive was visualized. By placing the finger behind the nodule and pressing forwards, one gained the impression that the tumor was discreet and circumscribed. Two transfixion sutures of medium size were placed through the deep substance of the tongue, one immediately anterior to the epiglottis and the second below the anterior pole of the tumor. A lenticular incision beginning at the anterior pole and extending to the posterior pole was made on either side of the tumor. The incisions were continued downwards to about the central portion of the tongue. A residuum of tissue was allowed to remain at the posterior pole. It was feared that a total resection of the tumor would remove all the thyroid tissue which the patient had. There was a surprisingly small loss of blood. The tumor had a fairly firm, elastic consistency and was a deep red color. The parenchyma was granular and fragile. In many respects it resembled normal thyroid tissue. A few cystic areas of degeneration were encountered. The superior surface of the tumor was covered by glistening mucosa in which there was a central small area, about 1 mm in diameter, presenting a somewhat translucent, brownish appearance. A true



FIG 13—Case 3. Photographs of the gross specimen of tissue resected from a lingual thyroid tumor. On the right the mucosa covering the tumor shows a minute dark area, indicating the probable location of the foramen caecum. On the left, a lateral view of the specimen.

depression or pit to indicate the position of the foramen caecum was not visualized. Several superficial, bluish vessels were noted. The edges of the wound were then satisfactorily approximated by means of chromic catgut sutures. The deep transfixion sutures previously placed were then tied lightly across the line of incision as a precaution against postoperative bleeding. The ligature through the tip of the tongue was allowed to remain for purposes of traction in case of postoperative difficulties. The operation was well tolerated.

Pathologic Examination—Gross The excised tumor (Fig 13) measured 2.3 cm in its anteroposterior diameter, 2 cm in its greatest transverse diameter and 1.4 cm in its vertical thickness. On the superior surface there was a central rounded area measuring 1.3 × 1.7 cm and covered with a glistening mucosa in which several small veins were seen. This rounded area was bordered by a margin of lingual mucous membrane. The inferior margin of the tumor was limited by a zone of whitish fibrous tissue. Incision into the tumor exposed a light pink, glistening, finely lobulated, glandular tissue of uniform character which gave the appearance of normal colloid thyroid. The stroma of the tumor was sparse and there were no areas of cyst formation, degeneration or hemorrhage.

Microscopic A sagittal section, representing the entire resected specimen was made (Fig 14). Anteriorly and posteriorly the lingual mucous membrane was fairly thick and composed of typical stratified squamous epithelium. Over the center of the tumor the mucous membrane was thinned out in a small area which corresponded approximately to

the location of the foramen caecum. In the thin submucosa there were groups of serous and mucous glands characteristic of the tongue. Focal areas of lymphoid tissue were seen overlying the posterior portion of the nodule. Everywhere the thyroid tissue composing the nodule was sharply defined from the musculature of the tongue, but nowhere was there a limiting fibrous membrane or capsule. The posterior irregular limits of the resected specimen indicated the line of transection of the posterior pole which was allowed to remain *in situ*. The bulk of the tumor was composed of large and medium-sized acini, which contained an homogeneous pink-staining colloid and which were lined by a single row of low cuboidal or flattened, granular or vacuolated follicular cells (Fig 15). The nuclei were rounded, oval or flat and pycnotic. Here and there were small areas of hyperplastic-appearing follicles showing papillary infolding of the lining cells. The interacinar stroma was scant throughout. The blood vessels were small and few in number and there were no areas of degeneration or hemorrhage. *Pathologic Diagnosis* Simple colloid goiter with small areas of hyperplasia.

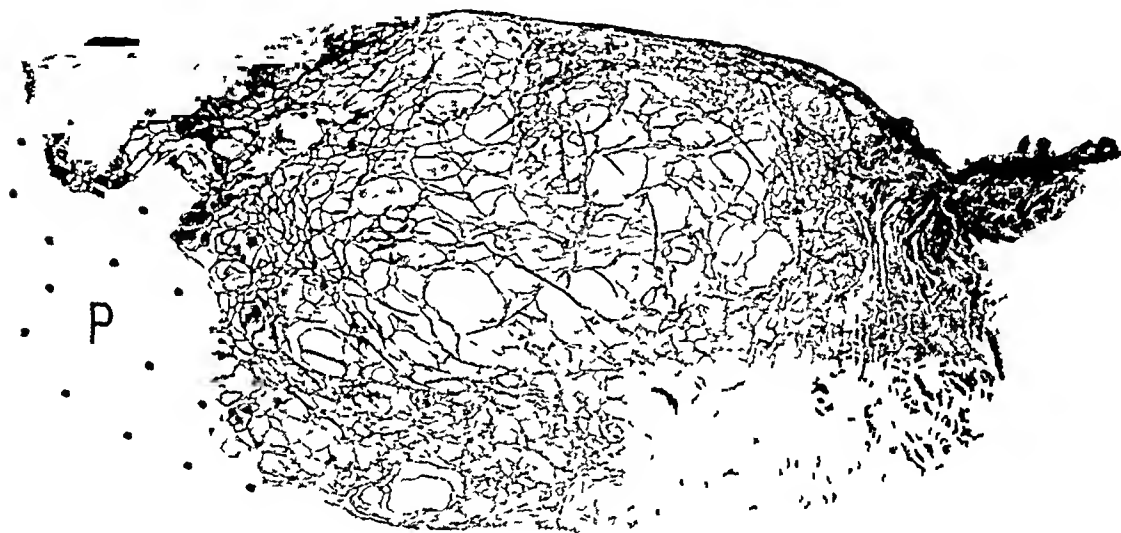


FIG 14—Case 3. Photomicrograph of a sagittal section of the resected specimen of lingual thyroid tumor, in the case of a girl eight years of age (Fig 12). The structure closely resembles that of simple colloid goiter. Note the absence of encapsulation. The dotted area (P) represents the posterior pole of the nodule, which was transected and allowed to remain *in situ* to prevent postoperative myxedema. ($\times 45$)

On the ninth day following operation the patient was briefly anesthetized and the sutures which had not previously sloughed out were removed, thus clearing the entire operative area. The posterior pole of the lingual nodule, which was spared, could be palpated. The patient was discharged on the 11th postoperative day, with normal temperature, pulse and respirations. Swallowing was comfortable and prompt.

Follow-up The patient returned for examination December 1, 1945, one month after operation. There had been a gain of two pounds in weight, and she showed definite evidence of a mild hypothyroidism indicated by puffiness about the eyes, a sleepy appearance, cold hands and feet and a facial pallor. She had complained of occasional sharp pains in the muscles of the neck and legs often seen in postoperative hypothyroidism. The difficulties of deglutition had disappeared and her appetite had improved. The throat was normal in appearance, there was no swelling at the base of the tongue and the area of operation was well healed. The pulse was 84. The patient had returned to school.

It is interesting that the level of cholesterol increased from a preoperative level of 271 mg per 100 cc of blood to 438 mg

Five weeks after operation, on December 8, 1945, the basal metabolic rate was minus 6 per cent. It had thus fallen 5.4 per cent below the preoperative level. In view of the mild hypothyroidism present the daily administration of one thyrothiamine tablet, containing one-half grain of thyroid extract, was prescribed.

The patient returned for further examination January 29, 1946, at which time it was stated that the former difficulties of deglutition had been practically relieved. There were

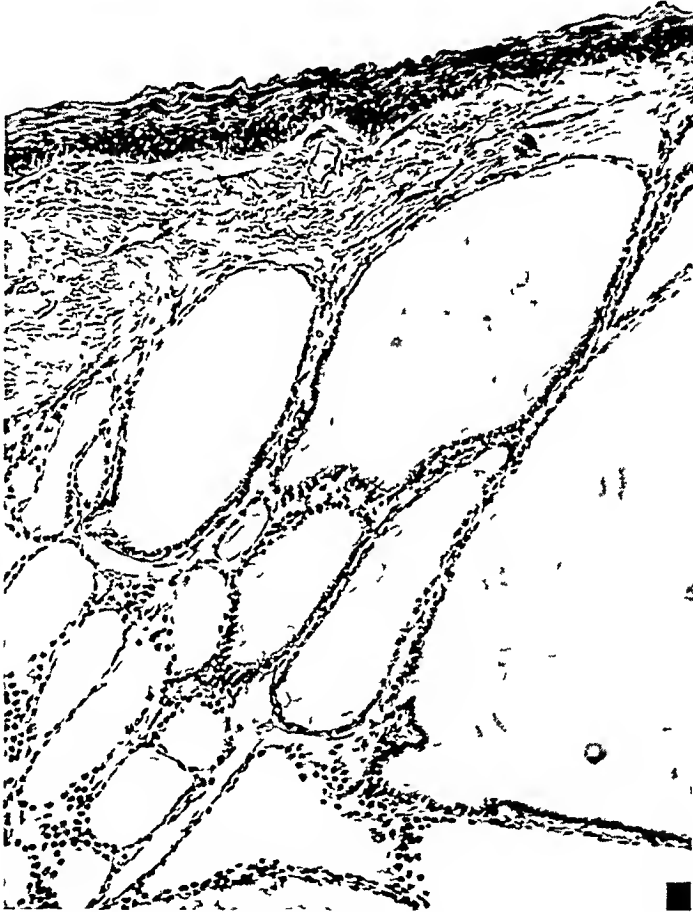


FIG 15—Case 3 Greater magnification, photomicrograph of section shown in Figure 14. Note the large distended colloid acini lined by a single layer of low cuboidal cells and the thin layer of mucosa covering the tumor ($\times 125$)

no complaints referable to the tongue and throat. Five weeks of therapy with thyroid extract gr 0.5 daily had produced a striking change. She was more animated and alert. The slight puffiness of the face and eyelids, as well as the pains in the muscles, had disappeared and the hands and feet had become warmer. The pulse had increased from 74 to 102. Her weight was 53 pounds, 3 pounds above the preoperative weight. The continued administration of one-half grain of thyroid extract daily was advised.

On March 28, 1946, five months following operation and after three and one-half months of thyroid medication, she was in excellent condition. There had been no return of the

manifestations of hypothyroidism and the pulse was 104. The throat was normal and there was no delay in swallowing. The weight was 54 pounds. The continued daily administration of thyroid extract gr. 0.5 was advised.

During the following three months, the patient was kept in good health by the daily maintenance dose of one-half grain of thyroid extract. She was growing noticeably, and her figure was becoming more slender. There was no recurrence of the tumor. The pulse averaged 96. At the time of her last visit, September 21, 1946, she weighed 57 pounds, having gained 3.5 pounds in three months. Her height June 11th was 114 cm. and September 21st was 123 cm., an increase of 9 cm. in three and one-half months. Thyroid gr. 0.5 daily was continued.

COMMENT The lingual nodule in this girl, eight years of age, caused difficulty in deglutition, an impediment in her speech and finally a mild hemorrhage. It was of homogeneous structure composed of a uniform hypertrophied thyroid tissue of the simple colloid type, as seen in the cervical thyroid. It could, therefore, correctly be called a simple colloid goiter. The child was undersized and showed evidences of a mild hypothyroidism. The goiter *per se* doubtless represented the only thyroid tissue which the patient possessed, for after partial excision of the tumor, the local obstructive symptoms were relieved but a definite moderate hypothyroidism with an increase in the level of blood cholesterol ensued. Excellent health was maintained with relief of all symptoms of hypothyroidism by the daily administration of one-half grain of thyroid extract. She gained in stature and appeared to develop normally. In retrospect, it would appear that this case undoubtedly might have been suitable for medical therapy such as one employs in the treatment of cervical colloid (endemic) goiter, namely, with minimal doses of iodine and adequate doses of thyroid extract. If we had known the histologic character of the lingual nodule before operation and had instituted medical treatment with thyroid extract and iodine, there is reason to believe that a satisfactory reduction in the size of the tumor could have eventually been obtained without operation. The length of time required may vary in the individual case.

Montgomery¹ reported a case in which medical therapy was instituted. However, the period of the treatment was too brief to expect more than a limited reduction in the size of the goiter as contact with the patient was lost.

DISCUSSION—There seems to be no general agreement among embryologists as to the origin and development of the thyroid gland. The origin of the lateral thyroid lobes and the part played by the ultimobranchial bodies in their development has long been a controversial subject. It is not intended to discuss this difference of opinion in the space of this review but rather to refer to a brief recent account of the embryology of the thyroid given by Arey,⁷ which is probably accepted by most students of the subject.

The main mass of the thyroid gland develops from an evagination from the ventral pharyngeal wall, which becomes the thyroid diverticulum. The latter quickly becomes a solid mass attached to the pharynx by a narrower neck. Even at four weeks, the diverticulum may be bilobed. The neck is known as the thyroglossal duct for the reason that it temporarily connects the primitive thyroid with the tongue, at the aboral border of the tuberculum impar. The thyroglossal

duct atrophies during the fifth week but its point of origin on the tongue, frequently indicated by an enlarged pit, is named the foramen caecum. As soon as the thyroglossal duct is set free, the thyroid is converted into an irregular mass of epithelial plates. Early in the seventh week, the gland becomes crescentic in shape and comes to rest in a transverse position at each side of the trachea. During the seventh week the ultimobranchial bodies, derived from the atypical fifth pharyngeal pouches, come in contact with the main thyroid primordium and fuse with it. These ultimobranchial bodies rapidly lose their original identity and are transformed into thyroid tissue. By the end of the fourth month the conversion into thyroid follicles is completed. It is generally agreed that thyroid tissue at the base of the tongue arises from the persistent median anlage or diverticulum which is derived from the ventral pharyngeal wall. This point of origin is subsequently indicated by a pit called the foramen caecum. On the other hand, some of the earlier anatomists (Keibel and Mall)⁸ inclined to the view that the ultimobranchial bodies constituted functionless rudiments and did not contribute to the formation of the lateral thyroid lobes. Others (Noir)⁹ felt that it was not certain whether the lateral anlage atrophies or eventually becomes transformed into permanent thyroid tissue.

It is probable that functional thyroid insufficiency is responsible for many if not most of the simple hypertrophies of lingual thyroid tissue. This view is supported by the fact that approximately two-thirds of the persons who have been reported as having a lingual thyroid hypertrophy were without a demonstrable thyroid gland in the neck. Furthermore, just as in the case of simple hypertrophies of the thyroid gland in the neck so it is with the lingual thyroid tissue whose susceptibility to hypertrophy is very marked during the maturing periods of puberty and early adult life. The etiology of those lingual nodules, presenting many of the changes characteristic of adenomatous goiter (Cases 1 and 2) is not clear, but probably the result of factors similar to those causative in the formation of the cervical thyroid adenoma.

In his critical analysis of 144 cases of lingual thyroid nodule Montgomery^{1,2} gives a detailed account of the symptoms, physical findings, pathology and treatment. It may be useful however to summarize these data and to add certain observations based on a critical study of the cases here reported. At least 90 per cent of the patients having a lingual thyroid nodule suffer from symptoms of pressure and obstruction such as dysphagia, dysphonia and dyspnea. In the three cases reported there were extreme dysphagia, choking spells (Case 1) and hemorrhage (Case 3). Less frequently reported symptoms were fulness and a feeling of tightness in the throat (Case 1). Pain was not a symptom in any of our cases. Authoritative instances of hyperthyroidism have not been reported in cases of lingual thyroid, nor was this present in our cases.

Thyroid insufficiency was reported in about 15 per cent of the cases analyzed by Montgomery, and only one of these was in a male. This finding was present in two of our patients (Cases 1 and 3). In both patients a cervical thyroid gland was not palpable. In none of the three cases was there any appreciable retardation of mental development. Our three cases were in females. This

bears out an interesting sex relationship. In the recorded cases symptoms have been described as developing during puberty and adolescence in almost half the cases, and during adolescence and early maturity in about three-quarters. In our cases symptoms began during childhood. It is probable that the factors which are operative in producing hypertrophies and pathologic alterations in the lingual thyroid tissue, are the same as those causing the well-known changes in the cervical thyroid. In the recorded cases the disturbed menstrual function was noted only in the severe degrees of thyroid insufficiency. In our adult patient (Case 1), age 30, in spite of a mild hypothyroidism menses began at the normal time. In our second case, age 12, there were definite evidences of approaching puberty. Our third case was only eight years of age. Pregnancy and occasionally menopause have been described as probable factors in causing lingual thyroid hypertrophy in some of the reported cases. In the adult female (Case 1) the hypertrophy existed before she became pregnant.

The only unusual physical characteristics of patients with lingual goiter are those associated with thyroid insufficiency, the manifestations of which are recorded in two of our cases (Cases 1 and 3). Otherwise the group, according to Montgomery, is singularly free from associated developmental anomalies.

The gross and microscopic findings in instances of lingual goiter are particularly interesting. The nodules have been described as large as a "duck egg" and the smallest represented by merely a group of thyroid acini. Our cases varied in diminishing size from that of a golf ball (Case 1) to that of a large olive (Case 3). As in our cases so in many of the recorded ones, the shape is described as globular, the surface smooth or somewhat lobulated, the color red to dark red. The surface vessels indicate a fair degree of vascularity. The cut-surface is often yellow to brownish-red, glistening and homogeneous. There are areas of colloid and areas of degeneration (Case 1) somewhat resembling myxomatous material (Case 2). These cases resemble in many ways the appearances often seen in cervical adenomatous goiter. Therefore, it would seem that the lingual thyroid is subject to the same pathologic degenerations as the normal cervical thyroid. Thyroid nodules exhibiting adenomatous changes have been stated to be greatly in the minority. However, two of our cases exhibited such changes. The majority of cases resemble more nearly the normal thyroid tissue (Case 3).

Eighty-five per cent of the lingual thyroid tumors in Montgomery's series were histologically benign. The normal type of epithelium predominated, whereas the fetal type ranked second. Several other lingual nodules of normal thyroid gland have subsequently been reported (Smith,¹⁰ and Lemmon and Paschal¹¹). Of the hypertrophies there is the simple colloid type, illustrated in our Case 3, in which the parenchyma is characterized by large acini, distended with colloid and lined by a single row of low cuboidal and flattened epithelium. This picture is the exact counterpart of the well-known cervical colloid goiter. Next in frequency are those forms produced by the embryonic or "fetal" thyroid tissue, which resembles the histologic findings seen in the fetal adenomas of the cervical thyroid (Rosedale¹² and Ray¹³). The parenchyma is characterized

by an abundance of small acini, and solid cords and groups of cells without well-defined structure (Cases 1 and 2) The colloid is usually scant in amount or entirely absent The appearance of hyperplasia may be found in an occasional area but has not been seen as we observe it in the diffuse toxic goiter Degenerative changes such as occur in the cervical adenomatous goiters may also be found in lingual goiters of the adenomatous type The histologic similarity of these nodules to that of cervical adenomas has not been sufficiently emphasized At least in two of our cases (Cases 1 and 2) a distinction would be difficult to make from cervical adenomatous goiter on the basis of histology Lastly, lymphocytic aggregates and lymphoid follicles were found in association with one of our cases (Fig 8, Case 2) A limiting membrane or pseudo-capsule much like that seen in cervical thyroid adenomas was present in two of our cases (Cases 1 and 2) In the instance of colloid hypertrophy (Case 3) a capsule was not present in keeping with conditions found in colloid cervical goiters

Carcinoma occurring in lingual thyroid has been reported in several authentic cases Tyler,¹⁴ in 1923, was the first, it appears, to report an instance of this kind There was metastatic involvement of the lungs and retroperitoneal nodes The second case of carcinoma was probably that reported by Ashhurst and White,¹⁵ in 1925 In 1935, Levi and Hankins¹⁶ reported an instance of low grade carcinoma occurring in a lingual thyroid nodule in a woman 26 years of age They described actual invasion of the tongue as evidenced by the irregular, poorly-formed acini and the "presence of tumor cells growing in strands between the muscle cells" of the tongue Montgomery did not regard the case as authentic and stated that the histologic picture might be merely a fetal pattern and that the intermingling of acini and muscle fibers had been observed even in benign cases He stated, further, that the occurrence of lingual thyroid carcinoma in the female had not been proved Wapshaw,¹⁷ in 1942, reported the case of a lingual thyroid which he first regarded as possibly malignant on the basis of its morphologic characteristics, the active epithelial proliferation and the intermixture of cellular masses and lingual musculature In the absence of metastases and in view of the benign postoperative course and because of the resemblance morphologically to the so-called fetal adenoma, he came to the conclusion that his case was really benign He collected 11 cases of carcinoma from the literature, and stated that the proven cases of malignancy occurred in males and that no confirmed case had been reported in a female There is much support, therefore, for considering lingual thyroid in the female as nonmalignant The diagnosis of malignancy, on histologic grounds alone, is very difficult The confirmation of metastases and the subsequent clinical course are required for a positive diagnosis Many of the lingual thyroids resemble the fetal adenoma of the cervical thyroid Similarly, they are capable of producing multiple types of epithelial overgrowth suggestive of malignancy These facts account for the reports of cases of histologic malignancy in which, however, there was no involvement of the regional nodes and which ran a postoperative, clinically benign course In view of the preceding it is well nigh impossible for the pathologist to make a final diagnosis on the findings in a biopsy *per se* The

fetal type of glandular overgrowth, whether in the lingual or cervical thyroid, is capable of producing various types of thyroid tissue. In one instance the tissue may resemble papillary hyperplasia as seen in diffuse toxic goiter, in another, the normal gland and finally a compact cellular overgrowth without the formation of acini but with intermixture of epithelial cells and muscle fibers suggesting invasion (Cases 1 and 2). These unusual findings have led to erroneous diagnoses of malignancy. It is, therefore, essential that many areas of the entire specimen be examined before a final diagnosis is made. For example, in one of our cases (Case 2) there were large areas which, in fact, resembled parathyroid tissue and led to the presumptive diagnosis of parathyroid tumor.

It is interesting that positively identified parathyroid tissue in close association with the lingual thyroid nodule has been observed in only one instance. Several bodies which resembled the parathyroid in structure were found in the pedicle of the tumor which was composed mainly of thyroid tissue. Myxedema and tetany followed complete extirpation of the tumor (Asch)⁶. Wood reported two cases of lingual thyroid tumors in which he found areas resembling parathyroid tissue. His illustrations resemble the structures not infrequently seen in lingual thyroids as well as in our Cases 2 and 3. As a matter of fact, areas resembling parathyroid tissue are not infrequently seen in fetal adenomas of the cervical thyroid. Dr. James Ewing was of the opinion that the tissue in Wood's case was probably not parathyroid but rather of fetal thyroid nature. In two of our cases there were areas in the lingual nodule (Figs 6 and 11) which in a definite way closely resembled the structure of parathyroid. In one of these Dr. Ewing favored the diagnosis of embryonal parathyroid tissue. However, after further study we were of the opinion that we were dealing with fetal thyroid of a type often seen in cervical adenoma. In the case of a myxedematous idiot, MacCallum and Fabyan¹⁹ found an aplastic cervical thyroid represented by mere rudiments of thyroid gland and only one pair of parathyroid glands was present. However, normal-appearing thyroid tissue was found at the base of the tongue. In a somewhat similar case of lingual thyroid and athyreosis, Ungermann²⁰ described the occurrence of one pair of parathyroid glands in the region of the trachea. In view of the fact that in these two cases of lingual thyroids only two parathyroid glands were found in each instance in their normal location, it is probable that the superior pair might well occur in the region of the lingual thyroid more often than heretofore supposed. This would probably explain why tetany does not occur when complete extirpation of a lingual thyroid has been performed. Presumably a cervical pair would still be functioning.

Diagnosis The physical findings in the reported cases and in our own cases are rather characteristic. Lingual thyroid nodules have been described in order of diminishing size, as being as large as an orange and as small as a pea. In shape they are spherical, rounded or oval. The surface contour is usually smooth, occasionally irregular. The color is dusky, purple, reddish, brownish or blue. The lesions are usually median in position, at or immediately posterior

to the foramen caecum and are attached by a broad base. Some are superficial, others penetrate into the deep substance of the tongue. In consistency the nodules are hard, elastic, soft, fluctuant or cystic. The mucosal covering is usually normal, occasionally ulcerative or hemorrhagic. Incidentally, it seems that two-thirds to three-fourths of the symptom-producing lingual nodules at the base of the tongue may be without a thyroid gland in the normal location in the neck.

Differential Diagnosis Lingual thyroid nodules are to be differentiated from adenoma, angioma, fibroma, lipoma and nonthyroid cysts, and the rare instances of malignancy such as sarcoma, lymphosarcoma and carcinoma. The actual number of benign, nonthyroid lesions at the base of the tongue is small. There were five cases of probable lingual thyroid carcinoma reported between 1910 and 1935, according to Montgomery. They were all in males over 35 years of age.

Treatment Since the outstanding symptoms of lingual goiter are usually the result of some degree of pharyngeal and laryngeal obstruction (Cases 1, 2 and 3), resort has usually, and correctly, been had to surgical treatment. When the lesions were located on the dorsum of the tongue, partial removal by the buccal route has been the usual procedure. Briefly stated, the steps of the operation are as follows. It is desirable to have the patient under complete anesthesia, which in our cases was accomplished by means of ether administered through nasal catheters. The head is placed in the overhanging, hyperextended position. The tongue is drawn well out of the mouth, and with forward pressure upon the posterior pole of the tumor, one obtains a good view of the tumor. Deep transfixion sutures are placed below the tumor through the deep substance of the tongue. These when tied, after the excision of the tumor, adequately control the bleeding which may momentarily be brisk. Elliptical incisions are made from before backwards through the overlying mucosa. The incisions are then carried downward in wedge-shaped fashion leaving a margin of nodule on either side and a portion of tissue at the posterior pole. Complete excision, except in the rare cases of malignancy, should, naturally, never be done. Additional mucous membrane sutures give a good approximation of the margins of the wound.

The surgical approach to the lesion has been varied according to the location and extent of the lingual tumor. Extra-oral procedures have been adopted in instances where the tumor is unusually large and has extended deep into the tongue or into the submandibular space. On such occasions submental or suprahyoid incisions have been employed (Wapshaw).¹⁷ Electrocoagulation or actual cautery has been used especially in cases of malignancy (Ashhurst and White,¹⁵ Levi and Hankins).¹⁶ Actual cautery is not advised in instances of lingual goiter where complete removal or destruction is to be avoided since the damage done to the residual thyroid tissue by these means cannot be accurately appraised. The same may be said regarding roentgenray and radium. Preliminary tracheotomy (Ray),¹³ with or without exploration of the neck to determine the presence or absence of a normally placed thyroid gland, has been

employed Preliminary ligation of the lingual artery has been employed in a few instances

The most disturbing, and also the most commonly expected complication of the surgical treatment of lingual goiter is thyroid insufficiency (Ray, Wapshaw) This occurred in two of our cases (Cases 1 and 3) in which it was mild to moderate and was adequately controlled by the administration of small doses of thyroid extract In our second case in which the diagnosis lay between atypical fetal thyroid and embryonal parathyroid tumor a satisfactory "follow-up" was not obtained and the ultimate postoperative condition was not determined The lapse of time before the appearance of postoperative hypothyroidism could not be determined in one of our patients because of the prompt administration of one grain of thyroid extract twice daily In Case 3, in which thyroid extract was not given in the early postoperative period, definite signs of a moderate hypothyroidism appeared within one month following excision of the thyroid nodule The occurrence of thyroid insufficiency following lingual thyroidectomy may be as high, it has been stated (Montgomery), as 65 to 70 per cent Transplantation of thyroid fragments has been done, in the hope of avoiding postoperative myxedema, but with unsuccessful outcome (Ray,¹³ Wapshaw)¹⁷

Biopsy and the employment of roentgenray and radium should not be considered unless the diagnosis of lingual thyroid cannot be definitely established Our experience with one biopsy examination was unsatisfactory (Case 2) because infection, sloughing and prolonged inflammatory reaction supervened These factors made subsequent surgical resection difficult and unsatisfactory In a case of lingual thyroid reported by Ray, preliminary treatment with roentgenray and radon seeds was given under the tentative diagnosis of malignant tumor of the tongue Infection and necrosis, which complicated the subsequent surgical excision and the convalescence of the patient, ensued The final diagnosis was benign lingual thyroid

It appears that lingual thyroid has never been successfully treated by medical measures These were attempted by Montgomery in a case of lingual thyroid treated with Lugol's solution A considerable diminution in size of the tumor followed but the period of treatment was not sufficiently long to determine the ultimate result of this treatment If we had known before operation that the lingual tumor in our patient, eight years of age (Case 3), was of simple colloid nature, it might undoubtedly have been reduced in size by the simple use of iodine and thyroid extract found to be effective in reducing the simple colloid hypertrophies of the cervical thyroid gland

SUMMARY

- 1 A critical study of three cases of lingual goiter has been reported
- 2 The pathologic histology of these three cases of lingual goiter has been presented, with particular emphasis on the structural similarities to adenoma of the cervical thyroid

- 3 The embryology, etiology, pathology, symptomatology, diagnosis and treatment has been discussed in relation to the three cases reported, and some of the pertinent literature

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CONCERNING SURGICAL TREATMENT OF TRAUMATIC INJURY OF THE UPPER DIVISION OF THE BRACHIAL PLEXUS (ERB'S-TYPE)*

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IN CASES OF INJURY of the "upper primary fasciculus" of the brachial plexus, (which is formed as a result of confluence of the 5th and 6th cervical roots) the classical method of choice is direct suturing after resection of neuroma and removal of scar tissue. Foerster, Babchin and we observed restoration of the function of *m. deltoideus* and *m. biceps* 6-18 months after operation. Having performed 82 operations upon the brachial plexus we became convinced that in many cases the defect, formed after removal of neuroma and scar tissue, is so great that direct suturing—to unite the divided ends of the upper primary fasciculus (or its elements)—becomes impossible. Recourse to transplants in such cases does not appear to hold much promise. In certain cases it is possible to employ implantation into the peripheral end of the divided upper primary fasciculus of some neighboring nerve which would serve as a neurotizer. Such nerves as *n. phrenicus*, *n. thoracalis longus*, or one of the *nn. thoracales anteriores* (a method used by Foerster, and by us) could be used for the purpose.

However, in many cases the damage may be so extensive that the above nerves cannot be employed with any hope for success. Sometimes there is a considerable difference in the dimensions of the neurotizer and of the cut-end of the upper primary fasciculus, so that it becomes doubtful whether the size of the neurotizer would be adequate to assure sufficient supply of growing fibers for the basic pathways of the peripheral end. We have made use of the neurotizers in a series of operations in which the neurotizers were implanted into the peripheral trunk of the plexus after it was isolated in the zone of injury. The remote results of such operations will be described elsewhere.

Our experience in the surgery of large destruction of single trunks of the *plexus brachialis*, led us to the conclusion that certain muscular branches of the plexus (those which could be used without impairing essentially the function of the extremity) could be profitably used as neurotizers for the functionally more important peripheral nerves, which had been traumatically severed. It seemed rational to neurotize the divided nerves as far distally from the zone of injury as possible. This is, of course, to assure optimal conditions of regeneration and, thus, to shorten the period of healing. The execution of the operation distally from the zone of trauma (and scarification) also makes the suturing, etc., technically much easier.

* Translated by S. A. Komarov, M.D., Ph.D.

The operation of neurotization, when indicated by exploration, can be conveniently carried out as the concluding step of the exploratory operation. In many cases, when the exploratory operation, for some reason, has been lengthy, neurotization can be carried out as a separate second-stage. Sometimes a preliminary examination of the scars and a study of the local changes in the zone of trauma permits a purely clinical diagnosis of the impossibility of restoring any function by means of surgery in the traumatized area. In these cases it is advisable to undertake neurotization from an incision made distally from the zone of trauma. While considering such a decision, one must have in mind that very often patients will not consent to undergo a second operation after the first has not brought about any functional improvement.

In traumatic lesions of the upper primary fasciculus (so-called Erb's paralysis), there is a loss of function of *n. suprascapularis*, *n. axillaris* and *n. musculocutaneus*, with atrophy of the corresponding muscles.

As a result of the study of topography on 100 cadavers we have concluded that the following nerves can be rationally used for neurotization of the above-mentioned nerves: *n. thoracalis longus*, *nn. thoracales anteriores* and *tricipitis* of the *n. radialis*, *n. thoracalis dorsalis*, and *n. subscapularis*—providing these nerves contain a sufficient number of the intact fibers. Foerster, and others, have successfully employed *n. thoracalis dorsalis* and *n. subscapularis* in cases of isolated injury of the *n. axillaris*. He also described a successful neurotization of the peripheral end of *n. musculocutaneus* with *nn. thoracales anteriores*. Analogous operations are described by Vulpius and Stoffel in their handbook. It should be mentioned that these operations were used separately in cases of isolated injuries of the axillary nerve and *n. musculocutaneus*, where the defect in these nerves after revision of the zone of injury could not be repaired by direct suturing.

N. thoracalis longus is usually formed by the branches from C5, C6, and C7, which emerge from the corresponding roots at the level of the processus transversalis. The roots from C5 and C6 pass through the substance of *m. Scalenus medius*. The most massive trunk from C7 passes laterally on the anterior aspect of the middle scalene muscle. Often, the main trunk of *n. thoracalis longus*, and the structures forming it, remain uninjured when the upper primary fasciculus is completely destroyed, and in such cases this nerve can be advantageously used as a neurotizer.

N. radialis gives off its branches to *m. triceps* rather high, at the level of the tendon of *m. latissimus dorsi*. At this level, or a little lower, *rami tricipitis* can be separated, tested with inductorium and used as neurotizers after having been turned upwards.

For neurotization of the axillary nerve we prefer to use two (from 3 or 4), *rami tricipitis* *n. radialis*, rather than *n. thoracalis dorsalis* or *n. subscapularis*, for the following reasons. *Nn. subscapulares* receive most of their fibers from the upper primary fasciculus and, therefore, in cases of Erb's paralysis, are mostly degenerated. The use of only two of *rami tricipitis* does not entirely deprive the *m. triceps* of its innervation, while the use of *n. thoracalis dorsalis*

for neurotization would entirely deprive *m latissimus dorsi* of its nerve supply. The cross-section of two *rami tricipitis* may not be smaller, and sometimes is even larger, than that of *n thoracalis dorsalis*, which circumstance makes implantation convenient. However, when some difficulties are encountered in the use of *rami tricipitis*, *n thoracalis dorsalis* can be used for neurotization of *n axillaris*, especially as it receives its fibers mainly from C7 and C8. *Rami tricipitis* receive their fibers from C7, C8 and T1. *Nn thoracalis anterior* are formed by the elements of the upper primary fasciculus and by the fibers from C7 and from the lower primary fasciculus as well.

Conclusions as to the functional adequacy and choice of the nerves to be used as neurotizers and as to the degeneration of the recipient nerves are formed from the clinical study of the state of the corresponding muscles, from the results of electrophysiologic examination performed before the operation, and, also, from the results of the stimulation with inductorium and determination of chronicity during the operation.

It should be mentioned, that if some of the fibers of the neurotizer are degenerated (the fibers from the injured plexus which find their way into the neurotizer as a result of exceedingly complex nature of the plexus) then, of course, the process of neurotization of the distal segment of the nerve—whose functional restitution is our aim—would be accomplished only by the intact fibers. In order to assure satisfactory neurotization of the recipient nerve, the intact fibers of the donor nerve should give off a considerable number of collaterals, during the process of regeneration. This is facilitated by a gentle handling, with the use of sharp instruments for cutting the nerve, and the avoidance of any tension. Being distributed evenly on the cross-section of the nerve, these intact fibers will supply the recipient nerve with a sufficient number of regenerating elements, particularly, if the diameter of the nerve donor approaches that of the nerve recipient. Incidentally, such a nerve donor, with only a part of its fibers degenerated, can show a fair functional capacity on being tested electrophysiologically. It should be remembered that the caliber of the nerve recipient, which has already undergone a process of Wallerian degeneration and atrophy, is considerably smaller than that of the corresponding normal nerve. This simplifies coaptation of the epineurium in suturing the nerve donor with nerve recipient. Experimental data of Kilvington, Kennedy, Feiss, Aird and Naftziger indicate that considerably thinner donor nerves, sutured end to end to the thicker recipient nerves, are capable of giving good neurotization of the recipient nerves, with restitution of the function, even if the ratio of the cross-sections is 1:2 or 1:3.

A case of neurotization with the use of *nn thoracalis anterior*, *n thoracalis longus* and *rami tricipitis* of *n radialis* in Erb's paralysis is presented here.

Case Report Patient N, female, age 20, was wounded, December 21, 1944, in left side of the neck, by a bomb fragment. She entered the hospital August 6, 1945. On the left side of the neck there is a large scar fixed firmly to the hardened and tender underlying tissues (Fig 1). Roentgenologic examination reveals deformation of the *processus transversalis* of C7 and a fracture of the first rib at the neck. Physical examination

shows pronounced atrophy of the scapular muscles, deltoid muscle (Fig 2) and biceps, complete absence of the function in the shoulder joint, except for adduction (after a passive abduction) on account of contraction of *m pectoralis* and *m latissimus dorsi*, complete absence of flexion in the elbow joint while extension is adequate, absence of supination, pronation adequate. Movements in the radio-carpal joint and also in the wrist and fingers are well preserved. There is anesthesia in the zone of innervation C5 and C6.

Extensive cicatrization, depth of paralysis and atrophies indicated a considerable destruction of the upper primary fasciculus and possibly also of the roots C5 and C6. These conditions made doubtful the possibility of restitution of the anatomic relations by direct suturing of the injured nerves *in situ*, and of regeneration after the operation. Predicated upon these reasons, and, also, because we did not wish to operate twice (as



FIG 1

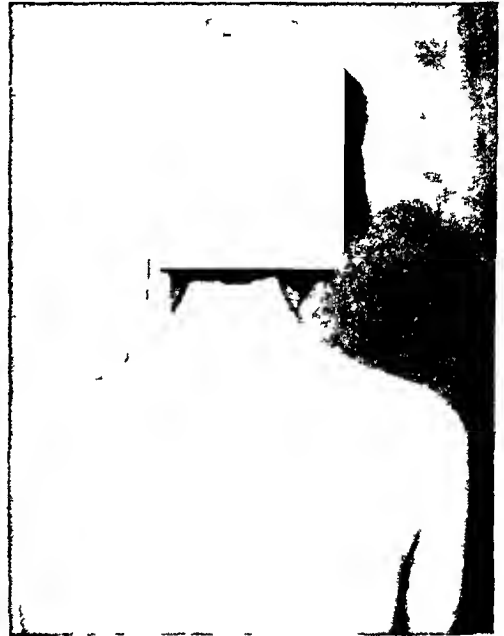


FIG 2

FIGS 1 and 2—Preoperative. Note atrophy about shoulder girdle.

the first operation above the clavicle, in our opinion, would be lengthy and not successful) it was decided to undertake implantation of the sound neurotizers into the peripheral nerves, with the aim not to impair essentially the remaining functions of the limb.

Operation—August 10, 1945, (Lurje). Incision from the clavicle to the borderline between the upper and middle third of the arm. *M pectoralis major* was separated from *m deltoideus* and from the clavicle for 5-cm., and then dissected at its insertion. Next the clavi-pectoral fascia and *m subclavius* were dissected. In the upper corner of the wound it was not hard to find the suprascapular nerve below the clavicle, while pulling slightly the outer (secondary) fasciculus of the brachial plexus. Stimulation with inductorium revealed complete degeneration of the nerve with absence of any response from the scapular muscles. *N thoracalis longus* was found below all the trunks of the brachial plexus. Stimulation of *n thoracalis longus* resulted in the contraction of *m serratus anterior*. This nerve was divided below the 2nd rib in such a manner that innervation of the upper two digitations of *m serratus anterior* was preserved, the nerve was then implanted with three fine silk sutures into the peripheral end of *n suprascapularis* which

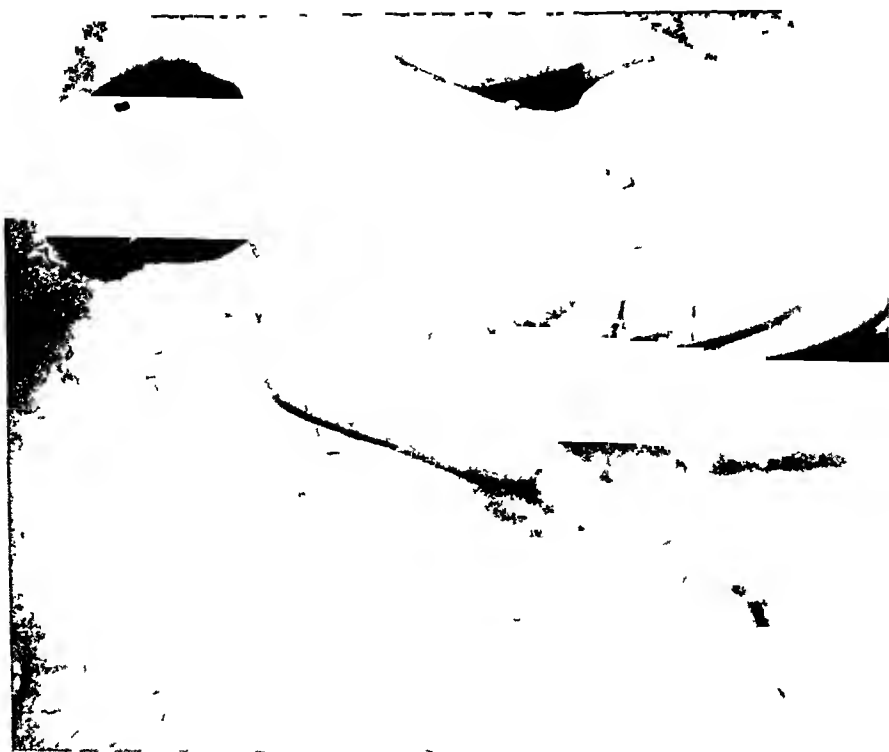


FIG 4

Figs 3 and 4—Five months postoperative (See text)



FIG 3

had been divided below the clavicle. The cross-sections of both nerves were nearly the same, as the suprascapular nerve was degenerated and atrophic. In the middle part of the wound we separated two *nn thoracalis anterior*. They emerged from the lateral secondary fasciculus of the brachial plexus (derived mainly from C7). After having verified their functional adequacy, we implanted them into the peripheral end of the previously divided (at its origin) *n musculocutaneus*. The caliber of both *nn thoracalis anterior* was comparable to that of *n musculocutaneus*. It was first necessary to isolate *n musculocutaneus* upwards from the lateral head of the median nerve with the aid of cutting instruments, the nerve was divided high, so that it would be possible to perform implantation while avoiding any tension. Implantation was made with four fine silk sutures.

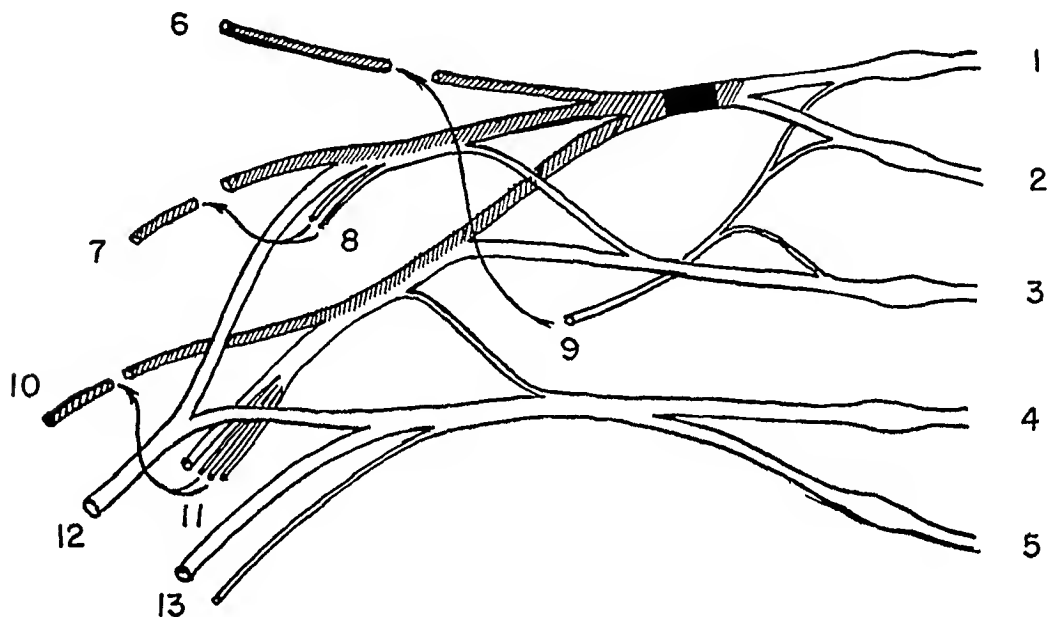


CHART I—1 5th cervical nerve 2 6th cervical n 3 7th cervical n 4 8th cervical n 5 1st thoracic n 6 Suprascapular n 7 Musculocutaneous n 8 Anterior thoracic n 9 Long thoracic n 10 Axillary n 11 Triceps ramus of radial n 12 Median n 13 Ulnar n

In the lower corner of the wound, we isolated three *rami tricipitis* of *n radialis*. Two of them were divided and turned upwards and implanted into *n axillaris*. The latter was cut on the anterior aspect of *m subscapularis* at its origin from the posterior secondary fasciculus of the brachial plexus and then its peripheral end was turned downwards. The caliber of the nerve donor and the nerve recipient were nearly equal (Chart I).

The wound was closed in the usual way and left with drainage for 24 hours. The postoperative course was uneventful.

Already, after two months, control examination revealed a definite improvement in the functions of *mm pectoralis* and *m triceps* (at the time of the operation their innervation was impaired by about two-thirds). At five months, after treatment with massage and faradization, there was some restitution of movements in the elbow joint, contractions of the deltoid muscle also appeared, and atrophy began to diminish (Figs 3 and 4).

Examination of the patient on October 10, 1946 (14 months after the operation) revealed a disappearance of atrophy of *m deltoideus* and *m biceps*, and a diminution of atrophy of the scapular muscles. The patient was able to contract *m deltoideus* strongly.



FIG 5



FIG 6



FIG 7



FIG 8

FIGS 5, 6, 7 and 8—Fourteen months postoperative (See text)

with abduction of the shoulder for 35° , while *m triceps* contracts maximally at the same time (Figs 5 and 6). Contractions of *m supraspinatus* were quite definite. In supine position the patient was able to maintain the limb in the vertical position by virtue of the contraction of *m deltoideus* (Fig 7). Flexion in the elbow joint was complete with distinct contraction of *m biceps* (Fig 8). The strength of *m biceps* is below that of the muscle on the right. Simultaneously with contractions of *m biceps* there are synchronous contractions of the somewhat atrophic *mm pectoralis*, and, similarly, contractions of *m deltoideus* are accompanied with synchronous contractions of *m triceps*. This phenomenon is analogous to that of synchronous contractions of the facial muscles together with contractions of muscles of the shoulder girdle, which can be observed after transplantation of *n accessorius willisi* into *n facialis* from half a year to a year after the operation.

Very interesting are the results of the chronaxymetric studies on our patient, which were carried out in the physiologic laboratory of the Neurochirurgical Institute (L. A. Novikova). Before the operation, *n axillaris* and *n musculocutaneus* gave a typical reaction of degeneration, and did not react on stimulation at a rheobase of 280v. After the operation, on October 4, 1946, *m biceps* did not react on stimulation at a rheobase up to 200v, in spite of otherwise good function and occurrence of distinct contractions. *M deltoideus* on the side of the injury gave chronaxy of 2.8G at a rheobase of 100v, while on the other normal side the chronaxy was 0.24G at a rheobase of 60v.

TABLE I

April 26 1947				
Right Arm Normal			Left Arm Operation	
G	F		G	F
a < k			a > k	
2.6 mA	3	<i>m supraspinatus</i>	8.0 mA	6.5
1.0 mA	3.2	<i>m biceps</i>	4.6 mA	3.8
2.4 mA	3.8	<i>m deltoideus</i>	5.0 mA	4.2

Absence of reaction of *m biceps* on electrophysiologic stimulation was not surprising to us, in spite of the fact that this muscle, both as to the function and the shape, was restored much better than *m deltoideus*. Our electrophysiologic studies on remote results of the operations on various nerves, had convinced us that in almost every case the regenerating nerve becomes passable for physiologic impulses much sooner (and more completely) than the regeneration can be established by the laboratory methods (with the use of ordinary chronaxymeters). Therefore, the clinical picture of functional restoration has a leading role in evaluating the progress of regeneration.

The subsequent electrophysiologic examination of the patient in April, 1947, established further restoration of excitability of *m deltoideus*, *m biceps* and *m supraspinatus* both to the galvanic and faradic stimulation. These results are given in the Table I.

(Examination was carried out on a usual electrodiagnostic apparatus in the Institute of Physiotherapy, Moscow.)

The following observation is also of some interest *M serratus anterior* gave before the operation chronaxy of 0.16G at a rheobase of 60v, 14 months after the operation the chronaxy was 0.28G at a rheobase of 65v. Both times only the lower segments of the muscle were studied. We consider that this phenomenon could be explained by the fact that *m serratus anterior* is sometimes innervated by the intercostal nerves, as our anatomical studies, presently in progress, have shown. Roentgenologic control of the osseous apparatus of the arm—before and after operation—established some diminution in the Sudeck's atrophy of the bones.

On the basis of our results, we feel justified in recommending the use of *n thoracalis longus*, *m thoracalis anterior*, *rami tricipitis* of *n radialis* (after proper physiologic examination) for neurotization of *n suprascapularis*, *n. musculocutaneus* and *n axillaris*. We regard this combined transplantation as a typical one in treatment of Erb's paralysis, in cases where the corrective operation *in situ* above the clavicle cannot be carried out. We believe that, in cases of upper Erb's paralysis, partial loss of the function of *m pectoralis* and *triceps* following section of two *rami tricipites* and two *m thoracales anterior* used for neurotization cannot make the function of the whole limb essentially worse. A part of the innervation of *m pectoralis* and of *m triceps* will be preserved, and, with proper exercise, the strength of these muscles can be restored, as we have seen in our patient. It is somewhat harder to evaluate the question of whether sectioning *n thoracalis longus* is admissible. While performing neurotomy distally from emergence of the fibers to two upper indentations of *m serratus anterior* we do not entirely deprive this muscle of its innervation. However, instead of *n thoracalis longus*, *n thoracalis posterior* can be employed for the purpose. The use of the latter nerve, according to Foerster, is already strongly indicated because exclusion of *m latissimus dorsi*, as an antagonist, will aid restoration of the function of *m deltoideus*.

On the basis of our experience with isolated injuries of the supraclavicular nerve, we regard its regeneration as important for the restoration of function of abduction in the shoulder joint and therefore its neurotization as desirable.

In our method of operation three physiologically important nerves *n suprascapularis*, *n axillaris* and *n musculocutaneus*, obtain fresh neurotizers with a good regenerative potential, and this, as our case well demonstrates, is of great importance for success in restitution of the function. In our opinion, the use of a freshly cut healthy nerve for the purpose of neurotization is a matter of great importance, since regeneration leads immediately to neurotization of the degenerated nerves. It is also important that in the zone of healthy normal tissues outside of the area of trauma, "ideal" conditions will be found for regeneration. Ordinarily, when in the case of gun shot wound, the injured nerve is sutured *in situ*, the regenerative process takes place twice. The first regeneration results in formation of a neuroma, the second regeneration takes place after the severed ends of the nerve are refreshed and sutured together, and only the latter results in neurotization. It is known, that with the passage of time after injury the capacity of axon and its cell to regenerate diminishes

(Foerster, Egorov, Chibumacher, Bondarchuk) Therefore, it is possible, that neurotization with fresh nerves, by our modification of treatment of Erb's paralysis, even when performed a considerable time after injury, will give better results than direct suturing after resection of the neuromas

SUMMARY

In the Erb type of paralysis, with considerable destruction of the upper primary fasciculus of the brachial plexus, where a corrective operation (restorative) cannot be technically carried out *in situ* with any hope of success, neurotization of the peripheral end of *n. suprascapularis* with *n. thoracalis longus*, of the peripheral end of *n. musculocutaneus* with *n. thoracalis anterior*, and of the distal end of *n. axillaris* with *ram. tricipitis* of *n. radialis* was performed. Prior to such an operation it should be established, by clinical and electrophysiologic examination, that nerve donors have sufficient potential capacity as neurotizers, and that nerve recipients are completely degenerated. Electrophysiologic examination should be repeated during the operation, and only after that the corresponding implantations can be performed. Under the above conditions, Erb's paralysis, with extensive trauma, indicates triple neurotization below the clavicle of the degenerated nerves according to the scheme presented, provided the tissues beyond the zone of cicatrization are normal.

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OBSERVATIONS UPON PATIENTS WITH PENETRATING WOUNDS INVOLVING THE CEREBELLUM

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AN ANALYSIS of 300 cases of penetrating cranial wounds due to metallic fragments observed at the 36th General Hospital revealed that wounds of the cerebellum were infrequent. Ten cases, an incidence of 3 per cent, were encountered. World War I reports indicate an even lower percentage of 0.54 per cent (6 cases in 1,108). In view of the variety in the types of lesions represented, illustrating the problems in management while in the Theater of Operation, these cases are briefly reviewed.

MATERIAL

The wounds were located on the left side of the cerebellum in nine of the ten patients and were caused by shell fragments in all but three. The latter were due to bullet wounds. In two cases, the dura overlying the cerebellum was not penetrated, but contused by the metallic foreign body. In three instances, the wound of entrance was located in the neck and the associated intracranial injury escaped attention. One in this latter group was treated and evacuated as a manic type of psychotic, a second (Russian POW), developed tetanus with a cerebellar abscess due to an inadequate débridement of the unrecognized wound.

One patient, who presented an acute cerebellar subdural hematoma, was successfully treated through expeditious management in the 38th Evacuation Hospital. Another presented an inflammatory complication associated with a retained metallic fragment in the posterior fossa. The removal of the fragment resulted in improvement. In two patients, tears of the lateral sinuses were serious complications at the time of the primary débridements. In each, the hemorrhage was controlled successfully by muscle stamps, one requiring three operative attempts. Severe basilar injury involving the cranial nerves and the internal carotid artery occurred in one instance.

Five of the patients were operated upon at the 36th General Hospital, the cerebellar injury having been overlooked in four of the cases. In five patients the operations were performed at Evacuation Hospitals.

GENERAL CONSIDERATIONS

A survey of the location of surviving cranial wounds, of all types, indicated that the anterior third of the skull was involved in 31 per cent of the cases, the

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parietal and temporal areas (middle third) in 54 per cent, and the occipital-cerebellar area (posterior third) in 13 per cent (occiput 10 per cent, cerebellar 3 per cent) As has been recognized in cranial injury due to causes other than penetrating metallic fragments, the highest mortality is associated with injuries which involve the posterior portions of the brain, the base and the areas contiguous to the vital centers A low incidence of survival may be one factor responsible for the infrequency of hospitalized cerebellar wounds Other factors most probably include the protected anatomic location of the cerebellum and the adequate covering afforded by the steel helmet made available in World War II

A wound of the cerebellum presenting the possibilities of rapid and serious complications calls for early operation They are, thus, in most instances, the problem of the evacuation hospital neurosurgeon

An uncomplicated wound was observed to be managed adequately by means of a unilateral curved cerebellar exploratory incision and the employment of conventional World War II methods of exploration and débridement of the wound entrance, the tract and the cerebellar lobe The operation, in our experience, was most wisely performed under general endotracheal anesthesia to insure control of the patient's respiration at all times while in the cerebellar position A posterior bur opening and ventricular tap prior to exploration was advantageous A ventricular tap was seldom required following operation

Adequate roentgenologic studies were essential in the preoperative estimation of the location and degree of bone injury and of the probable tract of the metallic fragment The diagnosis of a suboccipital injury may depend upon the technique used to obtain roentgen films of quality Views of the base in a mento-vertical and an occipito-vertical position were found to be advisable

Certain problems raised in the management of the complicated wounds may be reviewed more advantageously in conjunction with the patients' briefed record Several such summaries follow

CASE REPORTS

Case 1—*Acute Subdural Cerebellar Hematoma* A patient, B R, was wounded in action, January 2, 1944, at 0400 hours, and was reported as being unconscious for several minutes and unable to see for five minutes He vomited twice, one and one-half hours after injury and complained of severe headache A note of "stertorous breathing" was made at the Field Hospital shortly after injury He was admitted to the 33rd Evacuation Hospital in light stupor at 0120 hours on January 3, 1944 There he presented nystagmus upon right and left lateral gaze, hyperactive deep tendon reflexes, bilateral Babinski reflexes associated with a 15-cm wound in the left occipital area, 2 cm posterior to the mastoid tip Roentgen examination "revealed a 15 by 15 cm FB situated in the occipital region just to the right of the midline and 5 cm above the torcula" Operation was performed at 0400 hours, on January 3, 1944, by means of an inverted U-flap over the left cerebellar area "The dura was tense and blue The ventricle was tapped and the fluid was under extreme pressure" Before this procedure the patient's respiration fell to eight per minute Following incision of the dura "a massive solid subdural hematoma was evacuated" The debridement was then completed At the end of the operation the

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patient was fully conscious, and the respirations had increased to 18. Neurologic examination two days later showed a persisting nystagmus, but loss of the pyramidal tract signs previously noted. The patient's recovery was uncomplicated.

Follow-up A letter, dated March 14, 1946, stated that "I am working and, so far, I am in pretty good shape. My mind does not grasp ideas or problems that are complicated. Seems to me that my power of concentration has been impaired. Sometimes when I lay down I get dizzy for a moment or two. I never had any convulsion."

COMMENT The desirability of early definitive operation in the Evacuation Hospital was well-demonstrated, since further delay may well have resulted in fatality.

Case 2—Overlooked cerebellar wound in a patient with an intracerebellar clot. A patient, J. C., was wounded in action on May 11, 1944, at 1130, sustaining a "penetrating wound of the neck." There was no record of the patient's activity until May 14th, when he was admitted to a Battalion Aid Station. He was evacuated from this point with the diagnosis of "exhaustion." From a neuropsychiatric clearing company the patient was further evacuated, diagnosed as a postconcussion state. He had complained of severe headache associated with vomiting.

He was admitted to the 36th General Hospital on May 18, 1944, to a closed neuropsychiatry ward in a manic state, being completely uncooperative. A roentgenologic examination of the skull on the day of admission showed a comminuted fracture in the left occipital area, with indriven small bone fragments for a distance of 2 cm. Examination after transfer to the Neurosurgical Ward showed the patient to be alert, but disoriented, complaining of bursting headache, increased by any movement of the head. The head was held rigidly with posturing of the occiput to the left. Horizontal nystagmus was present upon left lateral gaze only. There was marked incoordination and ataxia in the left upper and lower extremities. The fundi were normal. There was an insignificant-appearing wound of the left side of the posterior aspect of the neck.

Under general anesthesia, a unilateral curved incision was made to expose the left suboccipital area. A perforation in the posterior fossa was exposed 2 cm to the left of the midline. The cerebellum extruded through the opening. The penetrated dura was tense after removing the overlying bone. As the dural opening was enlarged there was a sudden extrusion of clots and dark blood. This release of an intracerebellar collection of approximately 40 cc relieved all tension and the area began to pulsate. Debridement of the cerebellar lobe was then completed and the wound closed without drainage. The patient's recovery was uneventful in spite of the late débridement (9 days).

Follow-up A communication, May 3, 1946, stated that "I'm getting along just fine. I haven't been able to hold a job because if I do any kind of straining, I'm bothered pretty bad with headaches. I still don't have good use of my left hand. The Veteran's Administration recently cut my compensation to 50 per cent" (Fig. 1).

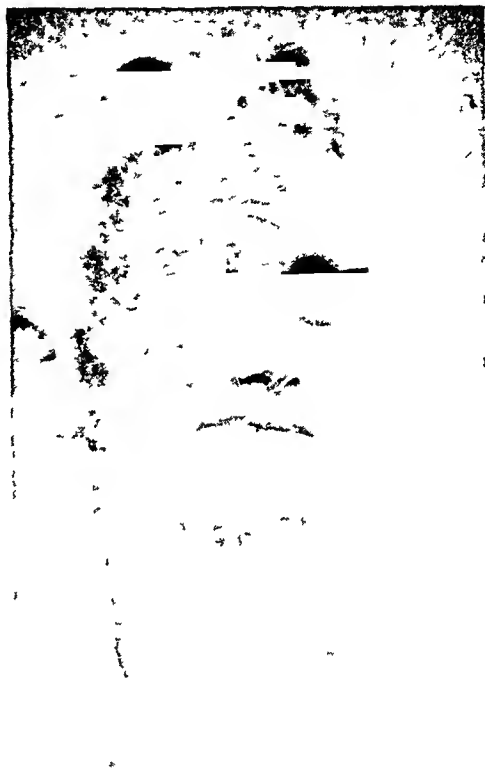


FIG. 1—Case 2. Recent photograph of this patient which was included with his communication of May 6, 1946.

COMMENT It was established in World War I that all minor-appearing wounds of the scalp be investigated for more serious underlying injury. Wounds of the neck must also be given similar consideration. It is of interest that of ten cases, in three the entrance wound was located in the posterior neck area, and all were overlooked as a locus for intracranial injury. This particular patient, fortunately, tolerated an intracerebellar clot which deserved earlier surgical treatment.

Case 3—Cerebellar abscess A patient, V K, (Russian P O W) was wounded, March 14, 1945, sustaining a penetrating wound of the left posterior aspect of the neck. He was admitted to an Evacuation Hospital six days following. A brief note described the removal of a metallic foreign body from the neck. The patient was transferred to a General Hospital, where it was recorded, March 28, 1945, that he had been irrational for 14 days, and was on that date disoriented, showed a memory defect, and complained of vertigo and diplopia. He presented bilateral papilledema, nystagmus and severe malnutrition. The patient remained apathetic, with a fever, until the 9th of April, when he developed "convulsions and became semicomatose." Nuchal rigidity and an opisthotonic posturing was noted. Roentgenologic studies of the chest showed bilateral advanced pulmonary tuberculosis.

The patient was admitted to the 36th General Hospital on the 10th of April, acutely ill, but conscious and oriented, complaining of severe headache. He presented an opisthotonus, with repeated tetanic spasms, which occurred on the slightest stimuli. A severe masseter muscle spasm was present. Examination showed two diopters of papilledema, with retinal hemorrhages, an abnormal plantar reflex in the left lower extremity, an infected wound in the left suboccipital area draining pus. The spinal fluid was under normal pressure and contained 9,000 white blood cells per cubic mm. A culture of the spinal fluid resulted in no growth of organisms. Detailed roentgenologic studies of the skull showed a comminuted fracture of the left occipital bone. Treatment with intravenous tetanus antitoxin, sodium sulfadiazine and sodium amytal was begun.

On the 11th of April, under local anesthesia, after ventricular tap and the instillation of 10,000 units of penicillin, the infected sinus in the occipital area was excised and the posterior fossa exposed through a straight incision. Extradural pus exuded through a perforation in the dura. The dura was opened and a welling-up of thick yellowish pus occurred. An abscess cavity, 3 cm in diameter, surrounded by a thin capsule was exposed. A rubber tube was placed just to the cavity and the wound closed after the instillation of 10,000 units of penicillin. The patient improved postoperatively. The spasms were difficult to control with sodium amytal, the "lockjaw" persisted. On the 12th of April, a series of tonic convulsions were associated with apnea, cyanosis and death.

COMMENT This patient presented a profound diseased state, including pulmonary tuberculosis, tetanus, meningitis, with a cerebellar abscess and malnutrition. The incomplete wound management resulted in tetanus, which was believed to be the direct cause of death. The opisthotonic state with tonic spasms was of interest, since late cerebellar lesions producing increased intracranial tension may result in tonic convulsions of this order. The associated trismus, the precipitation of the spasms by touching the patient or the bed and by noises, the alertness of the patient during the attacks clearly distinguished this state from that of the cerebellar tonic fit. At autopsy, the abscess was collapsed and the surrounding area showed little reaction to

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infection (Fig 2) There was neither a pressure cone at the base nor any basilar collection of exudate Cultures of the abscess showed growth of an anaerobic spore forming organism

Case 4—*A cerebellar wound associated with severe basilar damage* A patient, F G, was wounded in action, March 19, 1945, sustaining a shell fragment wound of the left posterior aspect of the neck and the inner canthus of the eye Superficial débridements were performed and the patient was evacuated The record was incomplete Upon admission to the 36th General Hospital, on March 23 the patient was acutely ill, presenting a

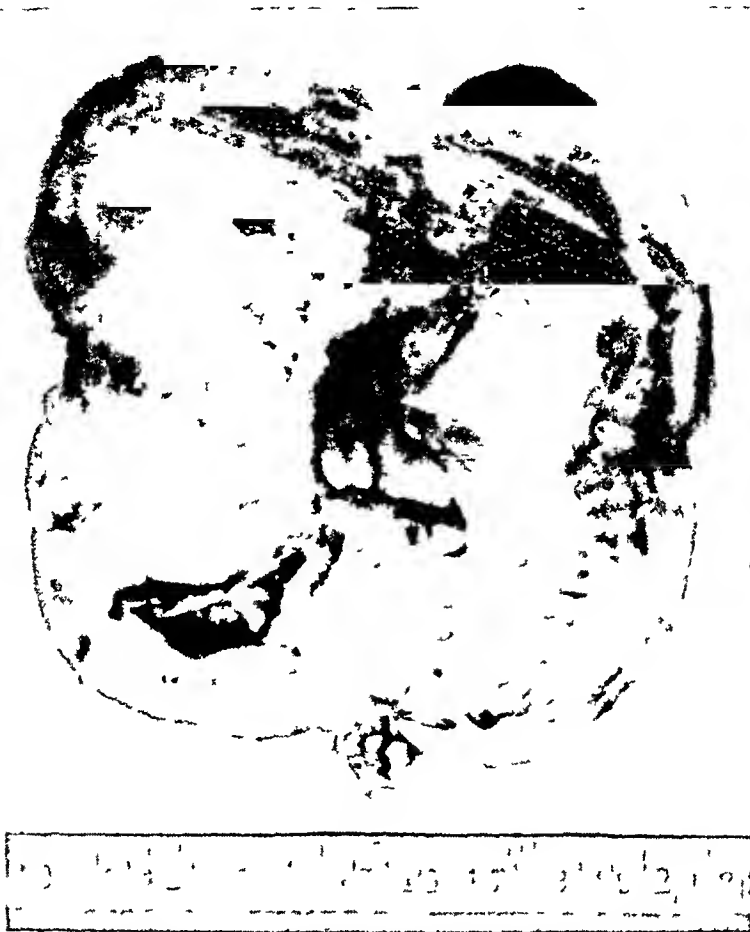


FIG 2—Case 3 Horizontal section through the removed cerebellum shows the collapsed abscess cavity on the left, measuring about 4 cm in length

subcutaneous emphysema of the neck and chest; moderate dyspnea and hoarseness; bilateral ecchymosis, with proptosis and a partial external ophthalmoplegia of the left eye The left external rectus muscle was functioning The left eye was blind, and the pupil was fixed There was a complete left peripheral 7th nerve paralysis and bleeding from the left ear The sensation of the left side of the face was disturbed No other cranial nerve or focal signs were noted at this examination The débrided wound in the neck was draining cerebrospinal fluid Roentgenologic studies showed a fracture of the left temporal bone extending into the auditory canal and emphysema of the chest and neck, suggesting perforation of the trachea or larynx

On the 24th of March an endotracheal anesthesia was administered with difficulty, due to an hemorrhagic and an edematous laryngeal mucous membrane Following the tract of the wound, an exploration of the left suboccipital region was made. The floor

of the posterior fossa was comminuted and the dura overlying the cerebellum was covered with clot, but was not penetrated. The missile had coursed inferiorly along the base of the skull. By retraction of the cerebellar lobe the jugular foramen was exposed and the 9th, 10th and 11th nerves were noted to be destroyed. The jugular vein, surrounded by clotted blood was intact. What appeared to be the petrosal sinus was severed and thrombosed. Bone fragments and debris were removed. Cerebrospinal fluid was observed to be flowing from the distal side of the transverse sinus in the depths of the tract. The wound was closed without drainage. Because of the edema of the larynx and the vagal paralysis, a tracheotomy was performed before removal of the intratracheal tube.

The patient's postoperative course was complicated by bronchopneumonia and roentgen evidence of widening of the mediastinal shadow considered as being due to a mediastinitis.



FIG 3(A)—Case 4. Photography of this patient during convalescence showing the results of the cranial nerve paralyses on the left side. The tracheotomy scar is demonstrated. (B)—Case 4. The wound of entrance and the postoperative scar of the left suboccipital area is demonstrated. There is atrophy of the trapezius muscle.

A severe sulfadiazine drug reaction also occurred. Neurologic examination during convalescence showed the following cranial nerve paralyses on the left side: II, III, IV, V (sparing of the ophthalmic division), VII, VIII, IX, X, XI, XII (Figs 3A and 3B). There were no other neurologic manifestations. The proptosis of the left eye receded. In the course of progressive improvement, a mass in the left tonsillar area was noted when the patient subsequently complained of pain and difficulty in swallowing. This was first considered to be of inflammatory origin. The mass continued to increase in size and swelling appeared at the angle of the mandible distal to the ear which began to hemorrhage. In spite of anesthesia in the 2nd and 3rd divisions of the 5th nerve, the patient complained of severe pain in the face. Aspiration of the pharyngeal mass revealed dark blood, it was nonpulsatile and no bruit could be elicited. A tiny incision into the mass resulted in brisk hemorrhage.

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On June 6, 1945, an arteriogram was made of the left internal and external carotid arteries. The contrast media did not flow through the internal carotid artery although injected directly into it. Visualization of the external carotid was normal. Following the arteriogram, exploration of the great vessels was made. The internal carotid artery at three inches from the bifurcation did not pulsate and the wall was readily compressible, having lost all resiliency, yet no point of obstruction was viewed. The external carotid appeared to be normal. The internal maxillary branch was ligated. The common carotid was exteriorized beneath the skin, for the purpose of speedy ligation if necessary. At the end of five days the mass had lost its firmness and bleeding from the left ear had ceased. The patient was then evacuated (Figs 4A and 4B).



Figs 4(A) and (B) —Case 4 Late photographs of patient 15 months after original injury, showing the remarkable degree of improvement in appearance

Follow-up The patient reviewed his subsequent course in a letter on February 26, 1946. He stated, in summary, that he was evacuated to Paris to await air transportation to the States. The day before leaving he hemorrhaged from the mouth and was operated upon. After convalescence he was transferred to the Ashford General Hospital. Upon arrival he immediately underwent an operative procedure on the left side of the neck. Ten days later "blood again rushed right out of my mouth and they again operated upon my neck and told me once again I would never have another hemorrhage. Well, I did not."

The patient gained weight from 100 to 157 pounds. A "plastic operation" upon his face was not performed "as my face has straightened up almost to normal by itself." The patient is "feeling fairly well now but I can't say that I'm fine. The thing that bothers me most is the steady noise that I hear in my head which started in July, 1945. It's a ringing noise and often times it gets severe with a loud knocking sound. The left side of

my face is still dead, also the left half of my tongue I cannot talk very loud, I cannot holler at all and have a hard time talking on the phone My left eye is still blind"

COMMENT This patient survived a remarkable degree of unilateral basilar damage involving the cranial nerves and vessels and leading to serious complications The degree of brain injury was minimal It is of interest that the missile was never located, and if it entered the pharynx, being swallowed or expelled, the pharyngeal wound of exit was not seen The nature of the vascular complication was not clear The mass appeared to be an hematoma, but this was disproved upon its incision which resulted in a steady stream of venous blood The characteristics of an aneurism were absent When the mass palpated during exploration of the neck, its size and tension could not be influenced by compression of the carotid arteries or the jugular vein Contrast media did not flow into the area of the mass Explanation for the failure of the internal carotid to visualize and its anatomical appearance cannot be given

Case 5—An inflammatory complication about a retained cerebellar metallic fragment The patient, M G, was wounded, November 14, 1944, sustaining a penetrating wound of the right occiput, with penetration of the tentorium and the right lobe of the cerebellum Examination at the Evacuation Hospital, November 15, 1944, showed a responsive patient, with a dysarthria and a left homonymous hemianopsia There was conjugate deviation of the eyes to the left, with nystagmus marked upon right lateral gaze The deep tendon reflexes were hyperactive and equal, rapid alternating movements were poorly performed, there was awkwardness upon finger to nose testing On this date exploration was begun by means of a right occipital incision The occipital lobe was debrided Upon exposure of the tentorial opening a suboccipital mastoid to mastoid incision was made and the cerebellum exposed The overlying dura was tense and blue Ventricular puncture produced little relief in pressure The cerebellar lobe was debrided, and troublesome hemorrhage was controlled by clipping a large vessel on the tentorial cerebellar surface The foreign body was not removed

The patient was admitted to the 36th General Hospital on the 24th of November At this date he was oriented but took little interest in his surroundings Coarse nystagmus was present upon right lateral gaze, the fundi showed blurring of both disk margins, a left homonymous hemianopsia was present There was weakness in the right lower extremity with more active deep tendon reflexes and bilateral Babinski signs The cerebellar status could not be accurately evaluated since the patient performed tests poorly through apathy The decompression site was tense Roentgenologic study of the skull "showed a large suboccipital decompression with the operative defect extending well up in the right occipital bone as high as the lambdoid suture There was a 1 by 1.4 cm foreign body situated in the posterior fossa 2 cm to the right of the midline and about 2 cm above the floor This placed the foreign body just above, medial and posterior to the internal acoustic meatus of the right petrosa There were a few small loose bone fragments at the operative site near the left lower margin of the defect" (Figs 5A and 5B) Treated by routine penicillin therapy, the patient failed to make satisfactory progress and the cerebrospinal fluid showed a pleocytosis of the 24-75 white blood cells per cubic mm with an increased protein Cultures of the spinal fluid at admission showed the presence of a gram-positive nonhemolytic streptococcus and a gram-positive nonhemolytic staphylococcus Subsequent cultures after the 26th of November showed no growth of organisms The decompression remained tense

Reoperation was performed under endotracheal anesthesia Pulped cerebellum was removed and a necrotic tract which extended into the vermis was debrided by aspiration

WOUNDS OF THE CEREBELLUM



A



B

FIGS 5(A) and (B) —Case 5 Preliminary film studies on admission to the hospital, showing large occipital defect following original decompression. A large metallic fragment is imbedded in the cerebellum



A



B

FIGS 6(A) and (B) —Case 5 Lateral and postero-anterior films following injection of air and after removal of the metallic foreign body, demonstrating the marked dilatation of the posterior portion of the body and the posterior horn of the right lateral ventricle. Considerable dilatation of the fourth ventricle following the loss of cerebellar tissue is also noted. There is some enlargement of the third ventricle, and also present is loss of air pathways over the posterior portion of the cerebrum and cerebellum

and the foreign body lying in the end of the tract was removed. There was no pus. Culture of the tract resulted in a growth of nonhemolytic staphylococcus. An encephalogram which was made on 20th of January, prior to evacuation, showed considerable dilatation of the posterior portion of the body and the posterior horn of the right lateral ventricle. This extended almost to the surface of the cortex. There was enlargement of the third ventricle and considerable dilatation of the fourth ventricle. There was obliteration of the subarachnoid pattern over the posterior portions of the hemispheres (Figs 6A and 6B). At discharge, the patient was ambulatory, with an ataxic gait. He was alert, oriented, having a cerebellar type of speech defect. There appeared to be severely impaired vision in the left homonymous fields. Nystagmus was present upon right and left lateral gaze, the papilledema had subsided. Severe incoordination was present in the right upper and lower extremity. The decompression was soft and the cerebrospinal fluid was normal.

Follow-up A report from the patient, March 13, 1946, stated that he was at home on furlough. His vision was severely impaired, having what he described as "travel vision." "Side vision" only was present in the right eye. "My left eye has fair vision but it gives me a lot of trouble due to pain in the eye. I still cannot walk straight and cannot write good. Three of my brothers and myself are in the dress chicken and egg business."

COMMENT This patient presented evidence of an unsubsiding infection as manifested by the pleocytosis of the cerebrospinal fluid, the positive cultures of the fluid and unimproving clinical status. The focus of the infection was the area of the tract about the metallic foreign body, which also cultured a pathogenic organism. The question arises whether or not penicillin therapy without reoperation may not have eventually sterilized this area. Treatment for 19 days was not effective in doing so. In our experience, large metallic fragments of this order should be removed, if accessible, at the least indication that an inflammatory complication exists. It has not been uncommon to find a localized abscess about such a foreign body, due apparently to the fact that the fragments are laden with tiny pieces of organic debris and bacteria.

RESULTS

The outcome in this group of cases was satisfactory. There was one death, resulting in a mortality of 10 per cent. This death, in a patient with an abscess of the cerebellum (Case 3), in fairness, may be attributed to tetanus rather than the cerebellar disease. The final result in the patient with severe associated cranial nerve and vascular injury (Case 4) is not fully established, and the disability is great. A third patient presented a peripheral facial palsy associated with unilateral deafness. The fourth (Case 5), has considerable visual impairment.

Six cases presented minimal neurologic defects. All were ambulatory. Cerebellar signs present upon admission improved remarkably except in the patient with the retained metallic fragment (Case 5). All the patients were returned to the Zone of Interior.

SUMMARY

1. An analysis of 300 penetrating cranial wounds showed that the cerebellum was involved in ten cases (3 per cent).

2 In three cases injury to the cerebellum was overlooked due to the location of the wounds of entrance being in the neck. Even minor appearing wounds of the posterior neck region may be associated with intracranial injury.

3 Wounds involving the cerebellum require early operation in the Evacuation Hospital, usually by means of an unilateral cerebellar incision under endotracheal anesthesia. Adequate roentgenologic studies are advantageous in the preoperative estimation of the location and the degree of injury.

4 The management of several cases of cerebellar injury which presented unusual complications were briefly reviewed.

5 The mortality in this group of patients was 10 per cent.

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THE SUBARACHNOID USE OF VASOCONSTRICTORS IN SPINAL ANESTHESIA*

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THE USE OF VASOCONSTRICTOR DRUGS has been recognized for many years as an important method of increasing the effectiveness of certain local anesthetic drugs. By delaying the rate of absorption of the anesthetic, the vasoconstrictor decreases the number of reactions and prolongs the duration of the anesthesia, thereby increasing the usefulness and safety of local and regional anesthesia. In the past, the practice of adding vasoconstrictors to the anesthetic in spinal anesthesia has met with little success, although a number of investigators^{1,7} have called attention to its possible value. The present report concerns the clinical effects of epinephrine and ephedrine when they are injected into the subarachnoid space with the anesthetic drug. These two vasoconstrictors were used because they have been the drugs most frequently employed in previous investigations.

It is interesting to note that it was not long after Braun⁸ first used epinephrine in local anesthesia at the beginning of the twentieth century that it was applied also to spinal anesthesia. In the years 1903 to 1905, Donitz and Bier^{9, 10, 11} reported that the addition of epinephrine to cocaine and stovaine in subarachnoid block resulted in anesthesia of greater effectiveness than did the use of these drugs alone. They believed that epinephrine both increased the length of anesthesia and decreased the toxic effects. In 1905,¹² epinephrine was also used with procaine in spinal anesthesia. For the next few years the custom of mixing a vasoconstrictor with the spinal anesthetic was common practice in some clinics. However, by the year 1915 the use of vasoconstrictor drugs in spinal anesthesia had fallen from general use. Some clinicians continued to use epinephrine with apparently good effect but the majority had become convinced that combining the spinal anesthetic with a vasoconstrictor drug was not only a needless but a dangerous practice.^{13, 20} In recent years several papers^{21, 22} have again appeared indicating successful results with the use of epinephrine in the procaine spinal anesthesia. The most recent report was published in 1945 by Prickett, Gross and Cullen.²³ They have found that the duration of procaine anesthesia is increased 30 per cent by the addition of epinephrine to the solution.

The vasoconstrictor properties of ephedrine are less pronounced than those of epinephrine, therefore, ephedrine has not been of value in local anesthesia. It has, however, been suggested as a means of prolonging the duration

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of spinal anesthesia In 1933²⁴ a mixture of cardiazol-ephedrine and nupercaine was used successfully Ten years later, Romberger²² reported that the addition of ephedrine to procaine increased the duration of anesthesia 40 to 50 per cent It should be pointed out, however, that some experimental work^{25, 26} has indicated that the subarachnoid injection of ephedrine may be accompanied by certain local or systemic reactions Evidence has been presented that ephedrine in the subarachnoid space may cause a marked rise in blood pressure or even interfere with the function of the nerves

Our experience with the injection of vasoconstrictor drugs into the subarachnoid space has been limited to the use of epinephrine or ephedrine with either pontocaine or nupercaine The total number of cases in which combinations of these drugs were used has exceeded 5,000 Our principal interest in this study was to decrease the dose of the anesthetic drug Our experience has indicated that this is an important means of increasing the margin of safety of spinal anesthesia This view has been supported by the fact that the incidence of severe circulatory and respiratory depression has been decreased by avoiding large doses of anesthetic drugs

The anesthetic effect of pontocaine and dextrose did not appear to be altered by the addition of epinephrine Ephedrine, however, definitely increased the extent as well as the duration of anesthesia produced by a given dose of pontocaine The pontocaine-dextrose-ephedrine mixture was prepared by adding sufficient 1 per cent pontocaine to a solution containing equal parts, by volume, of 10 per cent dextrose and 5 per cent ephedrine to make either a 0.20 or 0.33 per cent concentration of the anesthetic drug Both concentrations of pontocaine were used with satisfactory results The solution of pontocaine, dextrose and ephedrine was injected into the subarachnoid space without further dilution It was found that compared to pontocaine-dextrose alone, approximately 30 per cent less of the anesthetic drug was needed to produce comparable anesthesia Ephedrine apparently retards the rate of absorption of pontocaine from the spinal fluid We observed that with ephedrine the level of anesthesia was influenced by gravity for a longer period of time after the spinal tap Therefore, if the patient is placed in the head down position shortly after the spinal anesthetic is given, the danger of obtaining too high a level of anesthesia must always be considered The duration of anesthesia, using 10 mg of pontocaine or less, was increased about 20 per cent Experience with larger doses of pontocaine was too limited for us to formulate any conclusions

When epinephrine was added to hypobaric solutions of nupercaine, the anesthetic effect seemed to be increased The combination of epinephrine and nupercaine used was prepared in the following manner sufficient distilled water and 1:1000 epinephrine was added to a 1:200 solution of nupercaine, as supplied by the manufacturer, to make a 1:500 dilution of nupercaine containing a 1:25,000 concentration of epinephrine This solution was used extensively to provide muscular relaxation for intra-abdominal operations The hypobaric nupercaine-epinephrine solution was injected without further

dilution into the subarachnoid space with the patient in the sitting position. Following the injection the patient was allowed to sit up for one and a half to two minutes and then was placed in any desired position. All cases were immediately supplemented with a light plane of general anesthesia. With the technic described, the average dose of nupercaine necessary to obtain relaxation was 2 to 3 mg. for lower abdominal operations and 4 to 6 mg. for upper abdominal operations. In a limited number of cases small amounts of ephedrine were added to hypobaric solutions of nupercaine. Since the results did not seem to be significant, the method was discarded.

The subarachnoid injection of epinephrine and ephedrine, in the quantities and concentrations described, did not produce any systemic effects. There were no unusual respiratory or circulatory reactions. The blood pressure and pulse did not seem to be altered by the addition of these vasoconstrictors to the spinal anesthetic. It was our impression that the use of smaller doses of the anesthetic agent minimized the incidence of severe circulatory and respiratory depression. To maintain the blood pressure, an intramuscular injection of ephedrine, usually 50 mg., was routinely given prior to the spinal tap. Aside from the usual number of post-spinal headaches, there were no neurologic or other complications in this series.

Our experience supports the views of other investigators that the addition of a vasoconstrictor to the spinal anesthetic is a means of increasing and prolonging the effect of the anesthetic drug. All local anesthetics are apparently not similarly affected by the same vasoconstrictor drug. Previous workers have demonstrated that epinephrine potentiates the effect of procaine. With the particular drug combinations used in this study, epinephrine did not appreciably alter the anesthetic effect of pontocaine, but it did seem to enhance the potency of nupercaine. In contrast, ephedrine materially reduced the required dose of pontocaine, but it apparently exerted little effect when used in combination with nupercaine. Additional studies are, therefore, necessary to determine the optimum concentration of the vasoconstrictor as well as the most effective drug combinations for spinal anesthesia.

Whether the addition of vasoconstrictors to the spinal anesthetic is a real or only an apparent advantage remains to be determined by further experience. The ability to reduce the dose of the spinal anesthetic by the use of these drugs appears clinically to be of value, but it should not be assumed that proportionately less care need be taken in the administration of the anesthetic and the care of the patient.

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A METHOD OF PARTITIONING LIVER PROTEINS AND ITS APPLICATION TO THE STUDY OF THE EFFECTS OF ACUTE HEMORRHAGE IN THE DOG*

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A KNOWLEDGE OF THE PROTEIN reserve in man is of real importance in the proper medical and surgical care of the patient. The evidence in the literature,^{1, 2} leads one to assume that the liver acts as a store of plasma protein. The composition of the liver protein of an individual should then reflect the state of this reserve. Accordingly, an attempt has been made to develop a method for determining proteins in liver biopsy specimens. This method has been critically tested. In addition, the effect on liver proteins of acute hemorrhage in dogs has been studied with a view to securing a basis for interpreting results on human patients.

Ideally, the individual proteins of the liver should be separated quantitatively from each other by some means which does not result in their denaturation or in the production of artefacts. In practice this would be very difficult even with the aid of complicated electrophoretic and ultracentrifugal procedures. Empirical salt-fractionation methods are more convenient for partitioning liver proteins³ and provide results of physiological importance when careful control of all variables is maintained. The chief disadvantages of existing methods are the necessity for large specimens of liver, and the employment of long periods of dialysis and salt fractionation.

A method of estimating liver proteins suitable for use in the clinical research laboratory must be relatively convenient and reliable. In addition, only a fraction of a gram of liver would ordinarily be available. Bearing in mind these requisites, a procedure has been devised for determining liver proteins by nitrogen analysis after an initial separation into saline-soluble and saline-insoluble fractions. The former fraction may be further fractionated by strong sodium sulfite solutions. The proteins of the liver which are soluble in saline include albumin, fibrinogen, various globulins and those insoluble in saline consist mainly of connective tissue and cell membrane proteins.

METHOD FOR PARTITIONING LIVER PROTEINS

The fresh specimen of liver is made as free from blood as possible without expressing liver tissue fluid and is placed in a previously weighed glass vial,

* Aided by a grant from the Otho S A Sprague Memorial Institute

stoppered, and weighed. It is then transferred to a glass homogenizer, similar in design to the type used in preparing tissue homogenates for enzyme studies. Homogenization is carried out in the presence of 2 cc of 0.9 per cent sodium chloride solution. After a minute or two, when intact liver tissue is no longer discernible in the mixture, the homogenate is transferred to a graduated 15 cc centrifuge tube. Quantitative transfer is effected by homogenizing successive 2 cc portions of saline and adding these amounts to the first homogenate. The final volume of the homogenate is made up to 6 to 12 cc depending on the size of the specimen.

The saline homogenate is well-mixed and is centrifuged at 3000 r p m for 20 minutes. After the volume of the supernatant (A) is recorded, the saline-soluble material is decanted and preserved. That portion of the homogenate insoluble in saline remaining in the centrifuge tube is suspended in 2 cc of H_2O , centrifuged and the aqueous supernatant discarded. This washing out of the saline soluble nitrogen is repeated a second time leaving a residue (B).

The protein present in 1 cc of supernatant A is precipitated out by adding an equal volume of 20 per cent trichloroacetic acid and is collected by centrifugation (C). Another 1 cc of supernatant A is added to 7 cc of 22.2 per cent sodium sulfite solution, mixed well, stoppered, and is left overnight at room temperature. Protein material flocculates out in this interval and is separated from the solution by centrifugation yielding a residue (D) and the supernatant.

To each of the precipitates obtained in steps B, C, and D is added 1 cc of concentrated sulfuric acid solution which dissolves the residue so that it can be transferred quantitatively with the minimum amount of water to microkjeldahl digestion tubes. One cc of supernatant A is taken for nitrogen analysis. In addition to the concentrated sulfuric acid, knifepoints of sodium sulfate, potassium persulfate, 5 drops of 5 per cent copper sulfate solution are constituents of the digestion mixture. After vigorous digestion for at least 15 hours or longer (if necessary to complete the digestion), the contents of the digestion tube are transferred quantitatively with rinsing to a microkjeldahl steam distillation apparatus. The ammonia is trapped in 10 cc of 4 per cent boric acid plus 3 drops of mixed indicator (2 cc 0.1 per cent methyl red and 10 cc 0.1 per cent brom cresol green, both in alcoholic solution). Titration is carried out with 0.01N hydrochloric acid solution from a five milliliter microburette. Only freshly boiled distilled water may be used for rinsing the digestion tubes into the distillation apparatus. At least three reagent blanks are run with each day's determinations. The results are expressed as Gm protein per 100 Gm of liver.

The following terms have been employed to describe the nature of the various protein fractions. Supernatant A is considered to contain saline-soluble protein although a small fraction of the nitrogen is present in non-protein forms "polypeptides." This amount can be estimated by the difference between the value for saline-soluble protein and trichloroacetic acid "precipitable" protein (residue C). This "precipitable" protein represents the sum of

liver albumin and globulins. By subtracting the value of residue D which contains most of the liver globulin from the figure for residue C, the liver albumin may be approximated. Residue B contains saline-insoluble protein.

RESULTS AND DISCUSSION OF METHOD

Data are presented which show the influence of the volume of 0.9 per cent saline on the relative consistency of separation of saline-insoluble from saline-

TABLE I—*Effect of Volume of Saline on the Consistency of the Separation of Saline-Soluble and -Insoluble Material in Liver Tissue*

Wt of Liver Specimen Mg	Volume of Homogenate ccs	Saline-Soluble Protein		Saline-Insoluble Protein	
		Mg	Percentage of Liver Specimen	Mg	Percentage of Liver Specimen
96.9	3.7	7.76	8.0	6.53	6.7
94.7	3.9	8.28	8.7	6.14	6.5
109.4	5.9	9.30	8.5	7.15	6.5
127.8	7.2	10.70	8.4	8.24	6.5
140.9	10.9	11.30	8.0	9.66	6.9
138.8	10.6	11.75	8.5	8.51	6.2
Averages and deviation			8.3 ± 0.2	6.5 ± 0.2	

TABLE II—*Consistency of Results of Liver Protein Partition (Biopsies taken from different lobes of the liver peripherally and centrally)*

Wt of Specimen mg	Saline-Soluble Protein Gm %	Saline-Insoluble Protein Gm %	* Precipitable Saline Soluble Gm %	* Albumin-Containing Gm %	Globulin-Containing Gm %	* Polypeptides Gm %
200.5	10.68	5.94	9.40	7.33	2.07	1.28
186.8	10.21	6.23	9.00	6.26	2.74	1.21
191.3	9.99	6.21	8.52	5.14	3.38	1.47
154.8	10.09	6.12	8.65	5.59	3.06	1.44
32.7	10.45	5.68	8.21	5.87	2.34	2.24
Averages and deviation	10.3 ± 0.2	6.03 ± 0.2	8.78 ± 0.4	6.06 ± 0.6	2.71 ± 0.4	1.53 ± 0.3

soluble material (Table I). In another experiment, all fractions of liver protein as partitioned in the method have been determined (Table II). In both of these experiments, specimens were selected at random from different lobes of the liver, both from the interior and peripheral areas.

The data show that the volume of extraction medium may vary from 5–12 cc without materially affecting the efficiency of the separation of saline-soluble and insoluble material. It is evident also from Table II that relatively consistent analyses for the various protein fractions of the liver may be obtained with the method described in this paper. This same consistency has

been found with few exceptions in the analyses reported in the dog experiments

In preliminary experiments slightly more protein has been extracted when water was used in place of saline as the extraction medium. However, since consistent results were obtained by saline homogenization, it was decided to employ saline. It is true that the saline-soluble protein fraction is augmented slightly by the presence of blood protein left in the liver tissue spaces. One author³ has perfused livers with saline to free them of residual blood. Since it is impossible for various reasons to employ perfusion technics in our study of liver proteins, it has been necessary to use tissue which is not blood-free. From the data, this unavoidable error does not seem to be too important.

It is important to decide what physiologic significance (if any) to attribute to the various fractions. The saline-insoluble protein represents mainly the structural protein fabric of the tissue. The saline-soluble material contains albumin, fibrinogen, various globulins, many enzymes, proteoses, polypeptides, amino acids, urea, etc. This mixture can be separated by trichloroacetic acid precipitation into "precipitable" protein and "polypeptides," the latter term being used in a general sense to include the non-protein nitrogenous radicles in the mixture. The "precipitable" protein is regarded therefore as that protein in the liver cell which could function in the manner postulated by Whipple¹. The great clinical importance which is now being attached to the plasma albumin and globulin, made it seem desirable to attempt to fractionate liver albumin and globulin so that correlations with existing knowledge might be possible. The method of Howe⁴ based on the observation that globulin is selectively precipitated out by strong solutions of sodium sulfate or sodium sulfite⁵ was used as a guide. Many authors have employed this method in clinical studies of protein metabolism and have drawn important conclusions from the data. However, from work reported in laboratories where the method has been critically studied^{6, 7} it would appear unsound to consider the fractions obtained by salting out as containing only albumin or globulin respectively. Rather, it is evident that mixtures of albumin and globulin are separated in different proportions depending on the original albumin globulin ratio. Accordingly, in our study, we refer to the fractions thus obtained as "albumin-containing" and as "globulin-containing" with the implication that they are not systems of constant composition. There is greater variation in these fractions than in the other liver proteins which may be ascribed to the inadequacy of the salting out procedure. However, it was hoped that information of some value would be forthcoming in experiments on acute hemorrhage where extensive changes in liver protein were expected.

EXPERIMENTS ON EFFECTS OF ACUTE HEMORRHAGE IN DOGS

The liver protein partition procedure as outlined has been employed in studying the effects of acute hemorrhage on the composition of liver proteins

In these experiments, normal dogs (7-10 kilos body wt) were anesthetized under nembutal (25 mg per K) Employing aseptic technic, a small incision was made in the upper abdomen, a lobe of the liver was located, a hemostatic mattress suture was placed on the liver edge and a wedge-shaped piece of tissue removed The abdominal wound was then sutured The femoral artery was exposed, cannulated, and 120-200 cc of blood were allowed to escape slowly over a period of ten minutes About three hours later, the animal was sacrificed by dividing the aorta The liver freed of its gall-bladder was weighed Peritoneal fluid was collected measured, and its protein content determined Blood proteins were determined by Kjeldahl N analyses In each experiment at least two individual biopsy specimens were analyzed completely for liver protein at 1 hr and 4 hrs The results on six dogs are recorded in Table 3

In the acute hemorrhage experiments, when the averages of the duplicate analyses are compared, four out of the six dogs (Nos 1, 2, 3, 4) showed increases in the saline-soluble protein fraction which were due mainly to an elevation in "polypeptides" The trichloroacetic acid "precipitable" protein level was unchanged in all the animals except dog 5 in which it was lowered In three of the animals (dogs 1, 2, 3), there were definite increases in the amount of "globulin-containing" protein, with a corresponding diminution in the "albumin-containing" fraction Saline-insoluble protein was elevated in dogs 1, 3, 4, 5, unchanged in dog 6, but showed an apparent decrease in dog 2

DISCUSSION

In the acute hemorrhage studies, there are a number of factors of variation which should be considered before discussing the results In the first place, changes in tissue constituents other than the liver protein may be occurring, glycogen most certainly is disappearing from the liver, fat may increase, dehydration may occur The presence of fluid in the peritoneal cavity results from oozing at the site of the liver excision and its quantity and protein content has been measured The hemorrhage should be severe enough to result in a real depletion of plasma protein but should not be so extensive as to produce shock, with its accompanying disturbance to the circulation which would affect liver proteins in a manner difficult to predict An effort has therefore been made to reduce the amount of trauma connected with the removal of the biopsy specimens and to keep the incidental blood loss down to a minimum These considerations as well as the possible complication of infection have also led us to use a short period (4 hrs) of experimentation which may be too short an interval of observation It is clear also that the previous nutrition of the animal will alter the protein reserve so that the same amount of blood loss in two similar animals may have different effects on the composition of liver proteins Accordingly, it is to be expected that the results will differ from

PARTITIONING LIVER PROTEINS

TABLE III—*Liver Proteins Before and After Acute Hemorrhage*

Dog No	Time After Initiation of Experiment (hrs)	Wt of Specimen Mg	Saline-Soluble Gm %	Saline-Insoluble Gm %	"Precip-itable" Saline-Soluble Gm %	"Albumin-Containing" Gm %	"Globulin-Containing" Gm %	"Poly-peptides" Gm %
1	1 0	153 7	9 37	6 35	7 92	2 98	4 94	1 45
		388 7	9 62	6 90	7 71	2 61	5 10	1 91
	4 5	Averages	9 45	6 62	7 81	2 79	5 02	1 68
		136 1	10 39	7 50	7 61	0 10	7 51	2 78
		85 0	10 81	7 30	7 80	0 05	7 75	3 06
		Averages	10 60	7 40	7 70	0 07	7 63	2 92
Total blood loss 217 cc Initial and final plasma proteins respectively 4 9 4 8 albumin 3 5 3 4 globulin 1 6 1 4 gr % Total protein loss* 12 8 Gm								
2	1 0	114 2	8 64	6 20	6 53	2 73	3 80	2 11
		44 3	7 88	6 81			2 39	
	4 5	Averages	8 26	6 50	6 53	2 73	3 10	2 11
		182 9	10 62	5 32	6 77	1 95	4 82	3 85
		123 8	10 72	3 57	7 85	3 00	4 85	2 87
		Averages	10 67	4 44	7 26	2 47	4 83	3 36
Total blood loss 195 cc Initial plasma protein 6 4 albumin 5 0 globulin 1 4 gr % respectively Total protein loss 14 1 Gm								
3	1 0	110 6	11 68	7 75	9 20	3 27	5 93	2 48
		82 1	11 85	5 77	9 34	4 98	4 36	2 51
	4 0	Averages	11 76	6 77	9 27	4 13	5 15	2 49
		89 0	12 73	8 05	9 34	2 31	7 03	3 39
		127 2	13 03	7 48	10 22	2 40	7 82	2 81
		Averages	12 88	7 75	9 76	2 35	7 42	3 10
Total blood loss 143 cc Initial plasma protein 6 1, albumin 4 4 glob 1 7 gr % respectively Total protein loss 10 0 Gm								
4	1 0	114 5	9 43	5 52			2 53	
		104 8	11 03	5 84	9 39	6 71	2 68	1 64
	4 0	Averages	10 21	5 68	9 39	6 71	2 60	1 64
		91 5	11 79	7 17	9 52	6 56	2 96	2 37
		157 9	11 81	6 88	9 07	6 36	2 71	2 74
		Averages	11 80	7 02	9 30	6 46	2 83	2 56
Total blood loss 142 cc Initial plasma protein 6 7 albumin 4 1 globulin 2 6 gr % respectively Total protein loss 9 6 Gm								
5	1 0	106 0	9 98	5 24	7 86	3 68	4 18	2 12
		115 5	9 83	6 01	7 64	4 00	3 64	2 19
	4 0	Averages	9 90	5 62	7 75	3 84	3 91	2 14
		246 3	9 43	6 93	6 81	2 64	4 17	2 62
		123 9	8 62	6 43	6 73	2 53	4 20	1 89
		Averages	9 02	6 68	6 77	2 58	4 18	2 25
Total blood loss 154 cc Initial plasma protein 5 0 albumin 3 7 globulin 1 3 gr % respectively Total protein loss 7 5 Gm								

* Total protein loss is computed from the blood loss plasma protein and the protein content of the peritoneal fluid

TABLE III—*Cont'd*

Dog No	Time After Initiation of Experiment (hrs)	Wt of Specimen Mg	Saline-Soluble Gm %	Saline-Insoluble Gm %	'Precipitable Saline-Soluble Gm %	"Albumin-Containing Gm %	"Globulin-Containing" Gm %	' Poly peptides' Gm %	
6	1 0	128 7	10 61	7 13	8 12	3 90	4 22	2 49	
		179 3	10 00	6 15	8 31	3 28	5 03	1 69	
	4 0	Averages	10 30	6 64	8 22	3 59	4 62	2 09	
		196 5	10 68	5 69	8 33	4 00	4 33	2 35	
		227 8	9 80	7 16	8 23	4 93	3 30	1 57	
		Averages	10 24	6 42	8 28	4 46	3 81	1 96	
		Total blood loss 156 cc In tial plasma protein 5 8 albumin 3 1, globulin 2 7 gr % respectively Total protein loss 9 29							

animal to animal depending on how adequately the factors contributing to variation have been controlled

It is appropriate at this point to review the status of our knowledge concerning the formation and storage of plasma protein. It is fairly well established that protein moves into the circulation to replace that lost by hemorrhage^{8, 9}. It has also been shown that the liver is influenced greatly by the protein state of the individual, during periods of liberal protein intake both liver size and protein content increase most rapidly¹⁰ and the reverse is true during fasting and during periods of low nitrogen intake¹¹. On the basis of these and other considerations, Whipple and his associates have advanced the theory of a dynamic equilibrium between liver and plasma protein, with the liver normally maintaining a reserve of "labile" plasma protein available in periods of stress. This concept compels one to consider the protein in the liver as belonging to one of two discrete categories, one which is important for the life and efficient functioning of the cell, and one moiety which can leave the cell protoplasm in periods of stress, *i e*, after hemorrhage without affecting the activity of the cell. The best direct experimental evidence in the literature,^{3, 13} indicates that no single protein in the liver functions exclusively as a storage protein and that all proteins in the liver are similarly influenced by high (or low) protein intake. Luck¹³ considers "this equiproportionality of increase as indicative of a labile equilibrium *among the liver proteins* by virtue of which any tendency of a single member to accumulate is overcome by its secondary conversion into its fellow proteins." However different their viewpoints be, both Whipple and Luck envision a process by which one protein is converted into another by the regrouping of nitrogen fragments much larger in size than the amino acids, although smaller than the original protein.

The present results may now be discussed in the light of these considerations. A variety of effects have been observed from relatively minor changes in only one or two liver fractions (dog 6) to more definite alterations in most of the liver proteins (dog 1).

Importance has been attached to "precipitable" protein for the reason that it could possibly represent the protein available by one means or another, for blood protein replenishment. Does the failure of this fraction to be reduced except in one case mean that liver protein does not contribute to circulating blood proteins? Relevant to this question is the increase in saline-insoluble protein observed in four of the dogs. If this change were the result of dehydration or of the disappearance of glycogen, one would expect the "precipitable" protein to increase correspondingly. The failure for this to occur may be interpreted to mean that the liver does lose some of its protein substance after acute hemorrhage.

The elevation in "polypeptides" seems significant. It may be that the liver is more important as a site of rapid formation of plasma protein from units of protein structure (amino acids, polypeptides) carried to it from other regions of the organism. The observed increases may be the expression of an accumulation of such units.

The relative amounts of "albumin" and "globulin" in the liver varies from dog to dog. However, in three of the animals following hemorrhage, the "globulins" seem to be enhanced and the "albumin" correspondingly diminished.

If liver albumin constituted "labile" protein, then its departure into the blood stream should result in no change in "globulin" and in a decrease in both "albumin" and "precipitable" saline-soluble protein. Since "globulin" does not remain unchanged, it is difficult to point to "albumin" as a "labile" protein. If both liver albumin and globulin are being converted into plasma protein by the liver, the formation of new liver protein may take place through globulin which is later recast into albumin. This would be in accord with the concept of "interconversion of liver proteins" so that the normal partition is maintained. It may be significant that these alterations in the proportions of "albumin and globulin-containing" fractions occur in the animals which have suffered the greatest protein loss. However, in view of the unsatisfactory state of present methods for determining albumin and globulin all that can be stated definitely is that in some of the animals the physical properties of the saline-soluble liver proteins have been so altered that more of the globulin fraction is salted-out with sodium sulfite.

Summing up the results, one can visualize changes in the liver protein partition as a result of hemorrhage which seem to be made more evident in those animals which have suffered the greatest total loss of protein. These observations offer little support for the concept of a storage protein peculiarly labile and distinct in chemical and physiologic properties from the other proteins in the cell protoplasm. On the other hand, the alterations in the relative proportion of the liver proteins are more in line with some mechanism in which active synthesis of new protein is proceeding, with the liver proteins participating to an equal extent.

Although the mechanisms involved in plasma protein formation are

extremely complicated and difficult to approach experimentally, this study does reveal the possibilities which can be explored with a simplified liver protein partition procedure. It is believed that with more uniform conditions with respect to the nutrition of the animals, a characteristic pattern of changes in the liver proteins in the great majority of animals would be demonstrated.

CONCLUSIONS

A convenient method has been devised for the partitioning of liver proteins in small specimens of liver. Two main fractions of liver tissue are first prepared, one soluble and another insoluble in physiological saline. The saline-soluble material is further fractionated into "polypeptides," "precipitable" protein, "albumin- and globulin-containing" fractions. Reproducible results have been obtained. The inadequacy of present methods of determining albumin and globulin has been pointed out.

The composition of liver protein has been studied in dogs suffering from acute hemorrhage. In some of the animals there were increases in "polypeptides," "globulin-containing," and saline-insoluble protein. In most of the dogs, the concentration of protein soluble in saline but precipitable by trichloroacetic acid was little affected by hemorrhage. However, these observations along with other findings may be interpreted to suggest that the liver has lost some of its protein. These results have been discussed in connection with the problem of the formation and storage of plasma protein in the body.

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BLOOD AND LIVER PROTEINS IN SURGICAL PATIENTS AS RELATED TO PROTEIN DEPLETION*

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IN RECENT YEARS, the metabolism of protein has assumed an importance for the surgeon as great as any other subject. Operative mortality for gastrectomy has been shown to be directly proportional to preoperative weight loss¹. Resistance to infection decreases as depletion of proteins proceeds². Proper wound healing depends on adequate protein nutrition³. Gastro-intestinal motility decreases with hypoproteinemia at times simulating adynamic ileus⁴. A decrease in liver fat is effected by the administration of lipotropic proteins and amino acids⁵. Edema of anastomotic wounds, and abdominal wall wounds occurs in protein deficient states⁶. Postoperative asthenia is stated to respond to protein feedings⁷. Urinary suppression occasionally results from hypoproteinemia⁸. Abnormal losses of nitrogen occur after trauma^{9, 10}.

The above factors have focused attention on the relationship of blood proteins to tissue proteins. Experiments on animals with chronic protein depletion have shown that a decrement in the plasma albumin of 1 Gm per cent reflects a loss in the tissues of 30 Gm per cent¹¹. In humans, a low plasma protein value such as might result from an acute loss does not necessarily indicate that the tissues are depleted of protein. Peters states that the only absolute criterion of protein depletion is the establishment of a positive nitrogen balance. The inability to establish such a balance does not, however, signify that depletion has not occurred¹². Studies on tissue proteins have not lent themselves to direct analysis as in the case of blood proteins, and evidence has been secured in the main by inference from nitrogen balance studies. Low plasma protein values indicate a need for protein, but one cannot ordinarily appraise the significance of such values without some information as to the relation of low plasma protein values to tissue protein reserves.

In the experimental animal and in humans loss of plasma protein by hemorrhage or plasmapheresis or acute fasting, is at first rapidly restored without additional protein feeding^{13, 14, 15}. This and other evidence has led to the concept that there are available labile stores of preformed protein which the body can call upon in case of need. Additional evidence for such a depot is afforded by repletion experiments with plasma which do not lead to hyper-

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proteinemia The work of Whipple¹⁵ has indicated that a major depot for these "labile" protein reserves is in the liver

Let us consider two storehouses for protein One the liver protein, the other the total circulating protein What are the effects of depletion upon these reservoirs? If the protein reserves mirror the concentration of plasma protein, isolated plasma protein determinations would take on added significance as a measure of protein depletion

It is the purpose of this study to supply direct evidence so that the effects of protein deprivation upon blood and tissues can be correlated. Blood uric acid level has been reported to be a good index of the degree of protein depletion in surgical patients¹⁶ Its use as a criterion has been investigated as part of our study

METHOD

Liver biopsies for protein determination were obtained either by puncture through the abdominal wall with a Silverman biopsy needle,¹⁷ or in most cases at the time of operation when a wedge shaped segment was removed from a non-fibrosed area on the liver surface Plasma protein values were determined immediately before liver biopsies were obtained by either method Specimens secured during celiotomy were always taken at the beginning of the operation Plasma volume was determined immediately before surgery using Evans blue dye method¹⁸

Liver proteins were determined as described previously¹⁹ on 14 patients of whom four can be considered hypoproteinemic by the usual standards The clinical diagnosis, preoperative weight loss, blood proteins, plasma volume, and liver proteins are represented in Tables I and II

RESULTS

The Relation of Hypoproteinemia to Total Circulating Protein Blood volume is poorly correlated with body weight, being more closely related to surface area²⁰ Hypoproteinemic patients were found to have levels for total circulating protein per square meter of surface area (determined according to the method of Meeh's²¹) slightly lower than normals (Fig 1, Table II) The graph illustrates that there is a definite tendency for total circulating proteins per unit surface area to increase with an elevation in the total protein concentration of the serum, but the effect is by no means constant and individual values vary widely It can be said that the protein reservoir in the form of circulating proteins is by no means uniform and the magnitude of this reservoir cannot be appraised by simple blood protein concentrations The average total circulating protein per sq meter of surface area in those cases having total proteins of 6.5 Gm per cent or more was 120 ± 15 Gm per square meter of surface area When the total protein was less than 6.5 Gm per cent this value dropped to an average of 115, and when less than 6.0 Gm, an average of only 72 was found

In one patient (No 16 in Table III) an opportunity presented itself to study the effect of chronic depletion on total circulating protein This patient

TABLE I—*Clinical Diagnosis—Wt Loss and Blood Protein Studies*

Patient Number	Clinical Diagnosis	Pre Op Wt Loss in lbs	Gm % Blood Total Protein	Plasma Volume in cc	Grams Total Circulating Protein	Grams Total Circulating Protein Per Sq M Surface Area
1	Ca stomach	26	5 75	3217	185	138
2	Ca tail pancreas	10	6 64	3040	202	121
3	Ca esophagus	40	5 74	1020	58 5	47 1
4	Ca stomach	5	6 64	N D	N D	N D
9	Ca stomach	15	6 26	3149	197	150
10	Ca esophagus	12	7 78	3127	244	140
11	Ca pancreas	30	6 53	2912	190	109
12	Colostomy closure	30	6 58	1360	89 5	81 4
13	Cardiospasm	0	6 70	2440	164	111
15	Hemolytic Anemia	15	6 16	4234	261	179
17	Ca stomach	50	4 95	2544	126	102
18	Ca stomach	24	6 14	3307	203	117
19	Ca stomach	0	6 02	1737	105	65 2
20	Ca colon	0	6 54	N D	N D	N D
22	Ca stomach	20	5 52	3523	195	122
23	Normal	0	7 26	2538	184	116
24	Normal	0	7 21	2988	216	136
25	Normal	0	7 32	2816	206	122
26	Normal	0	7 68	3042	234	116
27	Normal	0	7 57	3014	228	132
28	Gastric ulcer	18	7 17	2106	151	96 3
29	Portal hypertension	0	7 16	3324	238	161

TABLE II—*Blood and Liver Protein Determinations of Patients Represented in Table I*

Liver Proteins (Gm /100 Gm Liver)												
Patient Number	Blood Proteins (Gm %)			Saline Soluble			Saline In-soluble	Ratio of Precap Saline to Insol	Total Sol Nitrogen Expressed as Protein	Blood Liver Protein Ratio	Liver A/G Ratio	Blood A/G Ratio
	Total Protein	Albumin	Globulin	Total Precipitable	Albumin	Globulin						
1 pre op	5 75	4 57	1 18	8 73	5 12	3 61	7 89	1 10	10 52	659	1 42	3 86
1A op	6 04	4 33	1 71	10 01	5 44	4 57	4 36	2 30	12 18	603	1 19	2 53
2	6 64	4 32	2 32	9 20*	4 03	5 17	N D	N D	11 22	825*	780	1 86
4	6 64	4 27	3 27	10 36	N D	N D	7 25	1 43	12 41	641	N D	N D
9	6 26	4 35	1 91	9 72*	5 15	4 57	6 37	1 52	11 78	646*	1 12	2 28
10	7 78	4 24	3 54	9 43*	3 54	5 89	5 72	1 65	11 43	825*	600	1 20
11	6 53	4 96	1 57	9 83	6 92	2 91	5 79	1 70	12 98	665	2 38	3 16
15	6 16	4 84	1 32	10 76	5 23	5 53	8 08	1 33	13 22	573	947	3 67
17	4 95	2 61	2 28	9 12	4 76	5 36	5 25	1 73	11 95	543	889	1 90
18	6 14	3 74	2 40	8 67	4 72	3 95	6 63	1 31	9 63	707	1 19	1 56
19	6 02	4 36	1 66	10 42	6 40	4 02	8 93	1 17	12 00	578	1 59	2 63
20	6 54	4 54	2 00	9 70	4 17	5 53	7 65	1 27	11 47	675	754	2 27
22	5 52	3 81	1 71	13 11	N D	N D	7 53	1 74	14 75	421	N D	N D
28	7 17	N D	N D	12 98	7 85	5 13	10 20	1 27	15 45	552	N D	N D
29	7 16	4 14	3 02	9 87	6 56	3 31	7 91	1 25	12 86	725	1 98	1 37

Determinations of blood proteins expressed in Gm per 100 cc

Determination of liver proteins expressed in Gm per 100 Gm of liver

* Result estimated from saline soluble nitrogen albumin fraction and globulin fraction

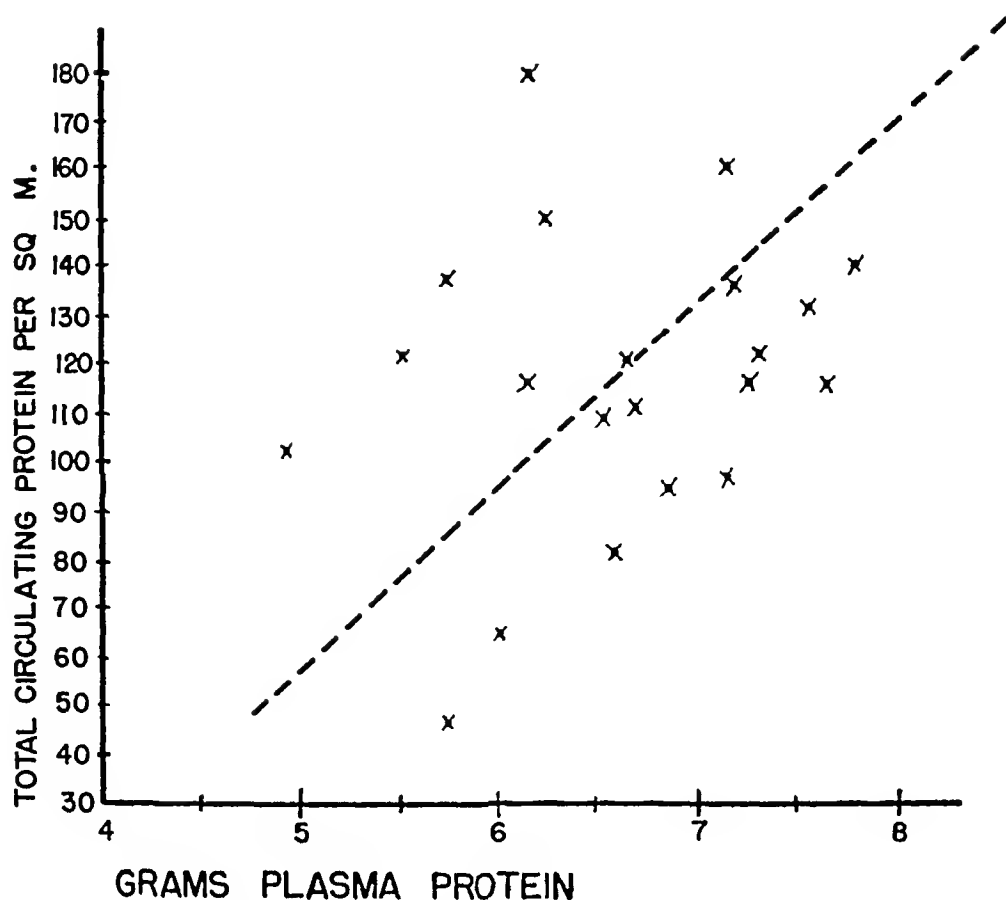


FIG 1—The relationship between plasma protein and total circulating protein per square meter of surface area is shown. The values for total circulating protein per Sq M. surface area tends to rise with increasing plasma protein concentrations as is indicated by the dotted line.

TABLE III—*Clinical Diagnosis, Weight Loss, Blood Protein and Uric Acid Concentrations in Patients with Hypoproteinemia*

Patient's No	Diagnosis	Wt. Loss in Pounds	Total Protein Gm %	Blood Uric Acid Mg %
1	Ca of stomach	26.5	5.75	3.65
3	Ca of esophagus cardia	40 (9 mos)	5.74	2.38
5	Cirrhosis and G. B. dis	20 (3 mos)	5.60	3.24
16	Postgastric Ca resection	Marked loss in hosp	5.26	2.99
*17	Subphrenic abscess Extensive Ca of stomach Inoperable	50 (1 yr)	4.95	3.54
22	Ca of stomach	30 (30 mos)	5.52	7.12
**30	Ca of stomach	52 (6 mos)	5.76	4.02

* 24 hour uric acid Excretion 215.2 Mg

** 24 hour uric acid excretion 169.0 Mg

had a subphrenic abscess and an internal pancreatic fistula following an extensive resection for carcinoma of the cardiac end of the stomach involving the esophagus and pancreas. The blood protein concentration fell from 6.26 to 5.26. The plasma volume decreased from 3,149 to 2,670. These circumstances effected a drop in total circulating protein from 197 Gm to 140 Gm.

Relationship Between Blood and Liver Total Protein Concentration—Figure 2 illustrates the relationship of blood proteins to total precipitable saline soluble protein of the liver. Again wide individual variations occur but

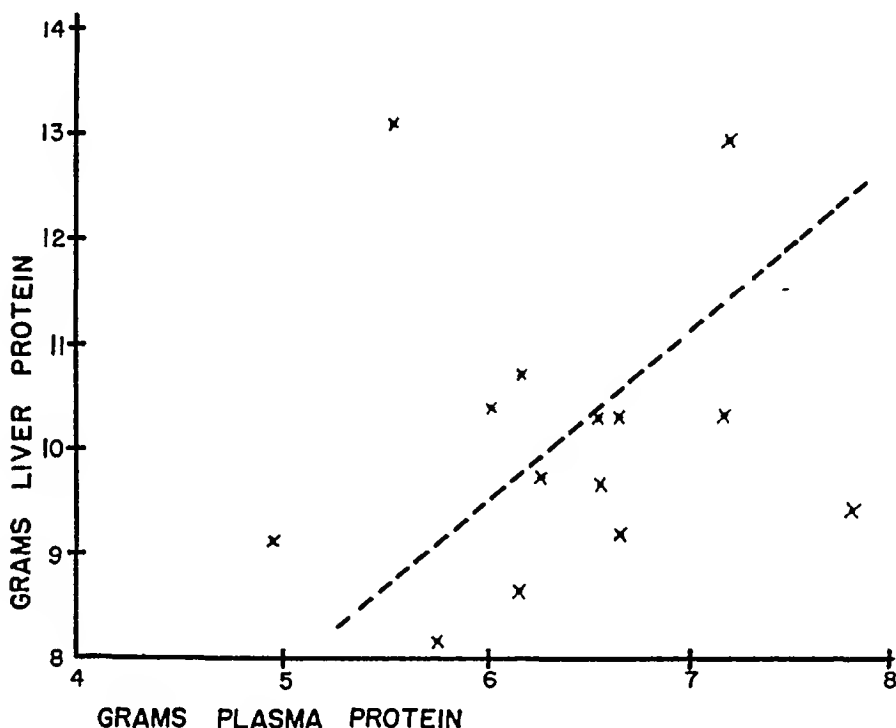


FIG 2—The relationship between total precipitable liver protein and plasma protein concentration is illustrated. With one exception, the liver protein concentration appears to increase with augmentation of plasma protein. This trend is designated by an interrupted line.

there is a trend toward liver protein accumulating with increasing plasma protein concentration. The normal value of total precipitable saline soluble liver proteins is in the range of 10.5 Gm per cent. If one examines the ratio of liver protein concentration to blood protein concentration, values occur between .42 and .72 with the low ratios in the hypoproteinemic group (Table II). This finding may possibly indicate that liver proteins are less subject to variation than blood proteins.

Liver and Blood Albumin and Globulin Fractions As pointed out in the previous paper,¹⁹ serious criticisms are indicated in the use of Howe's separation of albumin and globulin by salting out whether blood plasma or tissue preparations are used. Accordingly, these data must be interpreted with caution.

The albumin-containing fraction of the liver was not significantly lower in hypoproteinemic patients (Table II). Liver globulin-containing fractions are much higher than plasma causing a reduction of liver A/G ratios as compared to blood A/G ratios. In only one instance was a liver A/G ratio greater than 2.0 found. Although there is great variation in individual results, it appears from Figure 3 that there is a direct relationship between changes in the blood albumin globulin ratio and that of the liver.

Saline Insoluble Liver Protein The saline insoluble proteins of the liver represent the protein structural framework of the liver and as such cannot be considered available immediately for metabolic use under ordinary conditions.

This fraction is of basic importance since it provides a yardstick by which changes in the concentration of soluble protein may be considered absolute or relative. For instance, an increase in liver fat will lower the concentration of saline soluble liver protein even though the total amount of this protein is unchanged. By the same token, the concentration of the insoluble protein will diminish with an increase in fat. Nevertheless, the concentration of soluble protein per unit of structural protein will remain constant even though fat, glycogen and other substances change their individual concentrations. The establishment of a normal value for saline

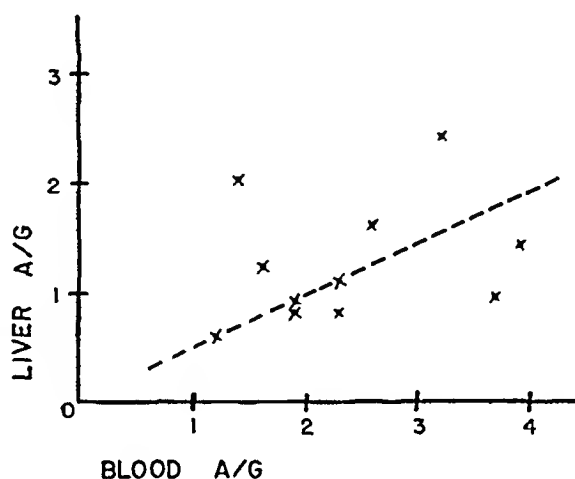


FIG 3—The blood A/G Ratio is plotted against the liver A/G Ratio. Except for a few results, variations in plasma protein composition seem to mirror similar changes in the saline soluble liver proteins. This tendency is represented by a broken line.

insoluble liver protein is of great importance in the interpretation of results. The average value for saline insoluble liver protein in those patients who were normal or in a good state of nutrition was 7.46 Gm per cent ± 1.01 (Table I). There were no significant differences noted in protein depleted states.

Ratio of Precipitable Saline Soluble to Saline Insoluble Liver Protein

This ratio is really the amount of precipitable soluble protein per unit protein structural mass, as was previously explained. If the liver is a storehouse for labile protein this ratio should be inconstant and fluctuate widely depending upon the amount of protein being stored. It will also be independent of the degree of hydration, fat content, and glycogen content. The ratios as expressed in Table II are all quite constant and lie between 1.11 and 1.73, a fact which diminishes the possibility of any large store of preformed plasma protein in the liver. As evidence for the validity of the statement that the ratio of precipitable saline soluble liver protein to saline insoluble does not change even with changes in fat concentration, one patient with advanced lipid dystrophy was studied. This patient even had an extensive enlargement of the liver and spleen. The values for precipitable saline soluble and insoluble proteins in

this case were only 6.50 Gm per cent and 5.37 Gm per cent respectively. The ratio was 1.21 which is in the region observed for normal patients (Case not included in tables)

EFFECT OF PLASMA TRANSFUSION ON LIVER PROTEINS

One patient with carcinoma of stomach (No. 1 in tables) was seen after a period of active bleeding and complete pyloric obstruction. He had lost 26 pounds in a period of 2 months. His plasma proteins were 5.74. He was given 3300 cc of plasma and 1000 cc of blood over a period of 4 days preoperatively. The first liver biopsy was obtained by puncture through the abdominal wall with a Silverman needle, after 1200 cc of plasma had been given the day before. The total precipitable saline soluble liver protein was 8.73 Gm per cent with an albumin fraction of 5.12 Gm per cent and determined globulin fraction of 3.61 Gm per cent. The saline insoluble protein was 7.89 Gm per cent. At the time of operation another biopsy was obtained. The total precipitable saline soluble protein had risen to 10.01 Gm, with an albumin fraction of 4.64 Gm and a globulin fraction of 4.57 Gm per cent. The saline insoluble protein dropped to 4.26 Gm per cent. That the protein concentration of the liver increased after the large plasma transfusions cannot be denied, but this does not necessarily indicate that intact plasma protein was stored as such.

The ratio of saline soluble to saline insoluble protein preoperatively was 1.10, operatively 2.37. This result seems to indicate that some of the infused protein was at least temporarily incorporated into the liver although it is difficult to state in what manner.

TOTAL SOLUBLE LIVER NITROGEN

Total soluble liver nitrogen was determined on all liver biopsy specimens. As a general rule, the total soluble liver nitrogen expressed as protein was in the neighborhood of 300 mg per cent higher than the total protein N. A portion of this non-protein nitrogen is urea, creatinine, uric acid, etc. There is a possibility that the remaining components may be amino acids, polypeptides, proteoses, or other split protein products. These would be the "building blocks" for plasma protein synthesis. The significance of a single determination of total saline soluble liver nitrogen is difficult to interpret, with repeated successive biopsies it becomes of greater importance.

BLOOD URIC ACID LEVELS AS A CRITERION OF PROTEIN DEPLETION

A recent report¹⁶ stated that blood uric acid levels were elevated in patients with hypoproteinemia secondary to gastric carcinoma and that the magnitude of the elevation was an index to the degree of protein deficiency. The rise in uric acid in their cases was interpreted as an attempt by the body to replenish the protein deficiency by means of an accelerated endogenous protein metabolism. Hyperuricemia was the evidence of this acceleration.

Plasma protein and blood uric acid levels were simultaneously obtained on 7 hypoproteinemic patients (Table III) and 20 normal patients (Table IV) In patients without hypoproteinemia and two patients with hypoproteinemia twenty-four hour uric acid excretion was studied. Determinations were made by the method of Folin²² There were no significant differences in uric acid blood levels or 24 hour excretion in the two groups

TABLE IV—*Clinical Diagnosis, Weight Loss, Blood Protein and Uric Acid Concentrations in Patients without Hypoproteinemia*

Patient's No	Diagnosis	Wt Loss in Pounds	Total Protein Gm %	Blood Uric Acid Mg %
2	Ca of pancreas	10 (6 wks)	6 64	3 27
4	Ca of stomach	5 (6 mos)	6 64	5 65
7	Lipoid dystrophy	0	6 40	6 68
8	Lipoid dystrophy	0	6 98	4 71
9	Ca of cardia	15 (4 mos)	6 26	2 26
10	Ca of esophagus	12 (3 mos)	7 78	4 17
11	Ca of pancreas	30 (6 mos)	6 53	3 43
12	Closure of colostomy	30 (6 mos)	6 58	4 17
13	Cardiospasm	0	6 70	4 84
14	Ca of stomach	0	6 77	3 74
15	Hemolytic anemia	15	6 16	3 90
*18	Ca of stomach	24 (2 mos)	6 14	3 10
19	Ca of stomach	0	6 02	4 44
23	Normal	0	7 26	4 00
24	Normal	0	7 21	5 84
25	Normal	0	7 32	3 67
26	Normal	0	7 68	5 97
27	Normal	0	7 57	5 48
**28	Gastric ulcer	18 (10 days)	7 17	3 98
29	Cirrhosis	0	7 16	4 02

* 24 hour uric acid excretion 148 1 Mg

** 24 hour uric acid excretion 325 9 Mg

Lenox²³ demonstrated that uric acid is retained in fasting states and an increase to as much as 14 mg per cent may occur after 5 days of fasting Brochner-Mortensen²⁴ mentions disease processes in which uric acid blood levels may be elevated because of faulty excretion It seems likely that if elevations in blood uric acid concentrations are occasionally found in hypoproteinemic patients they are purely on the basis of retention secondary to fasting

The work of Schoenheimer²⁵ with isotopic nitrogen has disproved the concept that there is a separate endogenous and exogenous protein metabolism, but rather that there is a common "metabolic pool" It would seem likely that in hypoproteinemic patients, all metabolic processes involving protein are spared to the same extent, and the rate of protein metabolism becomes lowered

DISCUSSION AND CONCLUSIONS

The protein reservoir in the form of total circulating plasma proteins although partially dependent upon the concentration of plasma proteins cannot be assessed by isolated plasma protein value. The total circulating protein per square meter of surface area is lower in hypoproteinemic patients.

The precipitable saline soluble liver protein per unit protein structural mass (ratio of precipitable saline soluble to saline insoluble protein) is maintained at a relatively constant level between 1 and 2 Gm per Gm of structural protein. The constancy of this ratio suggests that there are definite protein storage limitations in the liver and also that a certain quantity of precipitable saline soluble protein is retained by the liver cell for preservation of vital functions. The variations between 1 and 2 Gm per unit structural mass allows for a maximum possible storage capacity of 2.28 Gm of protein in a 1500 Gm liver. That such storage actually occurs at least temporarily is illustrated by the one case receiving a large plasma and blood transfusion. Since most ratios of precipitable saline soluble to saline insoluble liver protein are maintained closely in the region of 1.5 it is unlikely that ratios raised by plasma infusions remain high for more than a short time. Because this ratio is fairly constant there is a relatively large stationary protein mass in the liver. Such a situation tends to mask any small changes in protein concentration which may occur, and may have led some investigators to feel that there is no relationship between blood and liver proteins.²⁶

That liver proteins do participate in alterations occurring in plasma proteins is evident from the data presented. The rapidity with which changes may occur is demonstrable in the dog experiments.¹⁹ The results of both studies are therefore in harmony.

SUMMARY

A study was conducted on patients in order to evaluate and correlate the effects of protein depletion upon total plasma protein, albumin and globulin, total circulating plasma protein and liver proteins. The significance of the various protein fractions of the liver has been discussed.

Blood uric acid determinations have little value as an index of protein depletion.

Thanks is expressed to Dr D. B. Phemister for his assistance in the promotion of these studies. Thanks is also given to Mrs Evelyn Gordon for her technical skill in the performance of the many determinations.

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A SIMPLIFICATION OF THE DIAGNOSIS OF VARICOSE VEINS*

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AS OUR KNOWLEDGE of the pathologic physiology of varicose veins has increased throughout the years, numerous tests have been introduced into the literature which were designed to facilitate the diagnosis and treatment of this condition. It is evident from teaching experience, as well as from contact with the practicing physician, that the performance and interpretation of these tests appears to be a formidable undertaking which is discouraging to the new student, and far too time-consuming for the average busy practitioner to master.

In every treatise on the subject of varicose veins, one encounters a description of the following tests, the understanding of which would appear to be absolutely necessary before intelligent treatment could be undertaken:

- 1 Brodie-Trendelenburg Test
- 2 Comparative Tourniquet Test (Ochsner and Mahorner)
- 3 Perthes' Test
- 4 Compression Test
- 5 Schwartz Test (Percussion Test)

It would now appear that two of these tests have become obsolete and could well be disposed of entirely, and that one or two others are of largely academic interest. With this in mind, it was felt that a paper which might simplify the diagnosis and certain aspects of the treatment of varicose veins would be timely.

AN EVALUATION OF THE COMMONLY ACCEPTED DIAGNOSTIC TESTS

The above tests will be considered individually as to their performance, interpretation, and relative merit. Since most of our readers will be somewhat familiar with these tests, the description of the technic and interpretation will be somewhat brief.

I BRODIE-TRENDELENBURG TEST

This test was originally described by Brodie¹ in 1846, and popularized by Trendelenburg² in 1891. As originally described by Brodie and Trendelenburg, the test was devised only to demonstrate an incompetency at the sapheno-femoral junction. Since that time, however, numerous modifications have been introduced so that the present interpretation is much more comprehensive. The following is a brief summary of the performance and interpretation of the test.

Technic. The affected leg is elevated and the veins emptied by gravity. A tourniquet is then applied around the upper thigh, sufficiently tight to constrict the saphenous vein,

* This paper is based upon the personal treatment of over 3,000 patients with varicose veins and their complications at the Woman's Medical College, Bryn Mawr, and Delaware County Hospitals during the past ten years.

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but not the femoral vein. The patient then stands upright, and the degree of filling of the saphenous vein is noted with the tourniquet in place and again with the tourniquet removed.

Interpretation—Negative A negative test is one in which, with the tourniquet in place, the veins fill within a period of 30 seconds, and upon removal of the tourniquet, no increased rate of filling is observed (Fig 1). Here, it is apparent that no retrograde flow is taking place through the saphenofemoral junction, and that the filling was due to an incompetency of the communicating veins.

Positive In a positive Brodie-Trendelenburg test, when the patient stands with the tourniquet in place, the varicosities will remain collapsed throughout the 30-second



FIG 1—STEP I *Negative Brodie-Trendelenburg Test*

(A) Tourniquet On. Varicosities distended at end of 30-second period due to reflux from communicating veins.

(B) Tourniquet Off. No further distention of varicosities upon removal of tourniquet, indicating competency at the saphenofemoral junction.

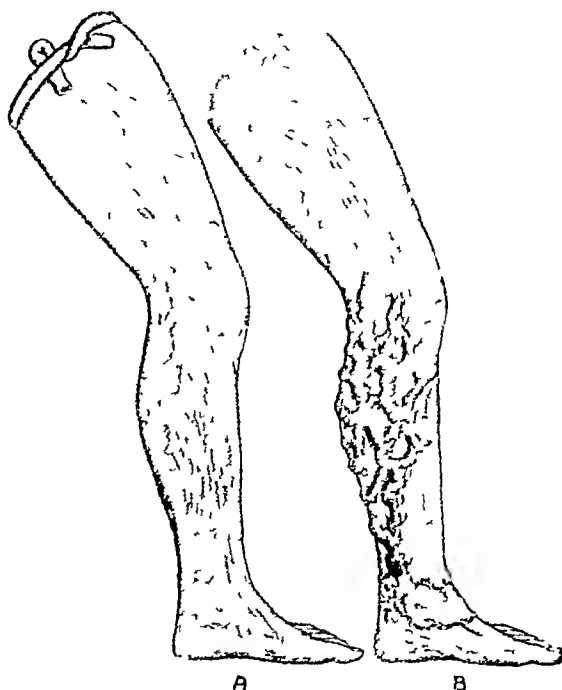


FIG 2—STEP I *Positive Brodie-Trendelenburg Test*

(A) Tourniquet On. The varicosities remain collapsed throughout the 30-second period.

(B) Tourniquet Off. Rapid filling of the veins occurs from above indicating incompetency of the valves at the saphenofemoral junction.

period, but upon release of the tourniquet, the internal saphenous rapidly fills with blood from above (Fig 2). Here, the valves in the saphenous vein at the saphenofemoral junction are incompetent, although the valves of the communicating veins are still intact.

Doubly-Positive A so-called doubly-positive test is one in which, with the tourniquet in place, the veins fill rapidly, and with the release of the tourniquet, even further distention of the veins takes place. In this case, the valves at the saphenofemoral junction as well as the valves of one or more communicating veins are incompetent.

Nil In a Trendelenburg-nil test, with the tourniquet in place, and again with the tourniquet removed, there is only slow filling of the veins from below. This would indicate competency of the valves of both the saphenous and communicating systems of veins.

It might be mentioned that considerable confusion exists in the literature between the Trendelenburg-negative and the Trendelenburg-nil tests as described above. In view of the fact that the Trendelenburg-nil demonstrates competency of the valves of both the

saphenous and communicating systems of veins, it would seem that such an individual would not have true varicose veins, and that this part of the interpretation of the test is unimportant

This test accomplishes two purposes. First, it demonstrates any existing retrograde flow of blood through the saphenofemoral junction. Secondly, it indicates the presence of one or more incompetent communicating veins between the superficial and deep venous systems, although it does not establish the level of such a vein. By its use, therefore, one may determine whether or not high ligation of the saphenous and its branches is indicated, and, secondly, whether or not an additional ligation at a lower level is necessary.

II COMPARATIVE TOURNIQUET TEST (OCHSNER AND MAHORNER)

This test was described by Ochsner and Mahorner³ in 1936 as follows:

Technic. The patient is draped so that both thighs and legs are visible, and he then stands before the observer who notes the size of the varicosities. The patient then walks to and fro, and the examiner again observes the prominence of the veins. Following this, a tourniquet is applied to the upper third of the thigh sufficiently tight to constrict the superficial, but not the deep veins, and again the size of the varicosities is noted with the patient walking. The same procedure is followed with the tourniquet applied to the middle, and finally to the lower third of the thigh.

Interpretation.—The interpretation of this test with the tourniquet at the upper third of the thigh is exactly similar to the Brodie-Trendelenburg test in that it demonstrates the relative competency of the valves of the saphenofemoral junction, and also designates whether or not any incompetent communicating veins exist lower in the thigh. The application of tourniquets lower in the thigh serves to designate the level of entrance of any existing communicating veins into the superficial system. Also, these tourniquets by occluding the superficial veins, would serve to reveal the presence of a deep femoral thrombosis, the theory being that if the deep veins were occluded by thrombus and the superficial veins by tourniquets, blood could no longer escape from the lower leg, and the varicosities present would tend to increase rather than decrease in size as the patient walks.

This test properly performed actually affords quite complete information as to the status of the superficial and deep venous circulations of the leg. However, much of the information obtained from this test is of purely academic interest, and is actually not essential to the intelligent management of the varicose vein patient. For example, one can demonstrate an incompetency at the saphenofemoral junction even more clearly in the Brodie-Trendelenburg test than in this test. One has also learned from the Brodie-Trendelenburg test whether or not any incompetent communicating veins exist below the level of the tourniquet. The actual level at which such an incompetent communicating vein exists is, in most instances, unimportant, since once the presence of such a vein has been established, low ligation of the internal saphenous below all of the communicating veins in the thigh will produce the desired result in the lower leg. The segment of dilated vein in the thigh extending from the incompetent communicating vein to the level of the low ligation can nearly always be satisfactorily obliterated by subsequent injection therapy. In the occasional case where such a varicosity would seem to persist, ligation of that communi-

cating vein might be advisable, but it has been our experience that the Mahorner-Ochsner test does not accurately localize its exact site. We have instead determined this level by marking the uppermost portion of the dilated segment, and making a vertical incision in this area through which the dilated vein is dissected upward to the site of the communicating vein which is then ligated.

A practical simplification of the Mahorner-Ochsner test, therefore, would be to perform the Brodie-Trendelenburg test, which, as stated previously,

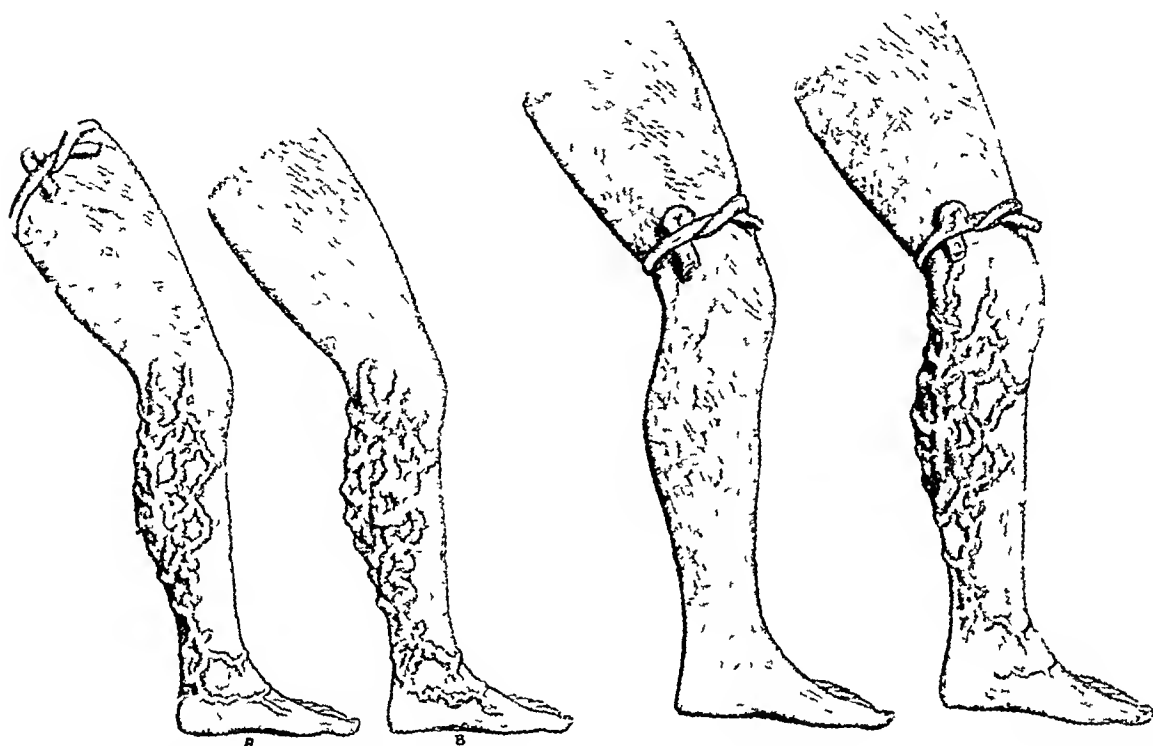


FIG 3—STEP I *Doubly-Positive Brodie-Trendelenburg Test*

(A) Tourniquet On. Some filling of the veins occurs within 30 seconds due to a reflux through incompetent communicating veins.

(B) Tourniquet Off. Further filling of the varicosities occurs due to incompetency at the saphenofemoral junction.

FIG 4—STEP II *Tourniquet Above Knee*

(A) Varicosities collapsed because incompetent communicating veins lie above tourniquet.

(B) Varicosities distended because incompetent veins exist below the level of the tourniquet.

demonstrates the presence of any existing communicating veins, following which a single tourniquet is applied just above the knee which will indicate whether the incompetent communicating veins lie above or below this level (Fig 4). If above this level, ligation just above the knee is indicated in addition to ligation of the saphenous at the saphenofemoral junction. In other words, by performing the Brodie-Trendelenburg test with this modification, the comparative tourniquet test is unnecessary insofar as its value in determining the type of treatment indicated is concerned. The value of the part of the comparative tourniquet test which deals with the status of the deep circulation of the leg will be discussed later.

III PERTHES' TEST

Perthes⁴ described this test, in 1895, as a clinical method of evaluating the status of the deep circulation in the leg

Technic With the patient standing, a tourniquet is applied just above the knee sufficiently tight to constrict the superficial veins of the leg, and the size of the varicosities in the lower leg is noted. The patient walks fairly rapidly to and fro before the observer, who continues to note the prominence of the varicosities.

Interpretation—Perthes interpreted this test in the following manner. If the deep venous system is patent, the superficial veins will actually become smaller due to the blood in them being drawn into the deep system. If the deep system is not patent, the superficial veins become more prominent since the blood has no way of escaping from the lower leg as both the superficial and deep systems are blocked.

Actually, a distinct fallacy in this test is the fact that occlusion of the deep circulation would have to exist at the exact level of the tourniquet for a positive test to be obtained. If an occlusion existed above or below the level of the tourniquet, a negative test might well result. Furthermore, as will be shown later, a knowledge of the status of the deep venous circulation is not essential to adequately treat the varicose vein patient. It is, therefore, evident that this test has little to recommend it, and may be discarded from future use.

IV COMPRESSION TEST

This test has been recommended as an additional method of determining the patency of the deep venous system of the lower leg.

Technic A compression bandage is applied from the toes to the knee just sufficiently tight to obliterate the superficial veins. Patient then walks for 30 minutes without stopping.

Interpretation—As was pointed out above, the Perthes' test revealed an obstruction only at the level of the application of the tourniquet, while this test was intended to reveal an obstruction at any level of the deep venous system of the lower leg. It was supposed that the compression bandage by obliterating the superficial veins, here, again, demanded that all of the blood in the lower leg must return through the deep venous system. If the deep venous system was obstructed by thrombus, the patient would complain of a cramp-like pain before the 30-minute period had elapsed since it was believed that the blood could not leave the leg through either the superficial or the deep veins. If the deep veins were open, the patient would be able to walk comfortably throughout the 30-minute period.

This test is impractical for two reasons. First, the time required for the performance of the test would prevent its general use, and, secondly, it is extremely difficult to apply the compression bandage with just the proper degree of compression. Moreover, as stated above, it will be shown that a knowledge of the status of the deep venous circulation is not essential in the treatment of varicose veins. Therefore, this test would seem to have little to recommend it, and we feel that it should likewise be discarded.

DIAGNOSIS OF VARICOSE VEINS

V. SCHWARTZ TEST (PERCUSSION TEST)

This test was described by Schwartz⁵ in 1897 as follows

Technic The fingers of one hand are placed over the saphenous vein at the sapheno-femoral junction. A varicosity above or below the knee is percussed with the fingers of the opposite hand.

Interpretation—If the valves of the saphenous vein are incompetent, an impulse is transmitted to the uppermost hand.

The results of this test are frequently unreliable, and any information obtained from it is more readily available from the Brodie-Trendelenburg test. Furthermore, Mahorner and Ochsner state that Ledderhose⁶ has quite conclusively shown that such a transmitted impulse is a normal finding in a competent saphenous vein. For these reasons, this test can certainly be eliminated from future use.

COMMENT. A review of the above would indicate that the Perthes', compression, and Schwartz tests have little to offer, are unreliable, and reveal no information which cannot be obtained by more accurate methods, and it is, therefore, our feeling that they no longer have a place in the diagnosis and treatment of varicose veins. It would seem that the Brodie-Trendelenburg test, with the additional feature of the tourniquet placed just above the level of the knee, as described above, will actually afford all of the information required for one to treat any uncomplicated case of varicose veins. As will be shown later, it is not even necessary to determine the patency of the deep venous circulation in order to institute adequate therapy.

DISCUSSION WITH RESPECT TO THE NECESSITY FOR THE EVALUATION OF THE DEEP VENOUS CIRCULATION

Throughout the literature, the determination of the status of the deep venous circulation has always been considered necessary before any effort was made to obliterate existing superficial veins. It was assumed that these superficial veins might be acting as collateral circulation around a point of obstruction in the deep venous system, in which case obliteration therapy would be contraindicated.

It has always seemed unlikely to us, however, that dilated, tortuous superficial veins, that is, typical varicose veins, whose valves must obviously be incompetent, could actually carry blood against the effect of gravity around a deep femoral thrombosis. Furthermore, it is difficult to understand how veins can be acting as collateral circulation when the Brodie-Trendelenburg test indicates a reversed flow of blood through them. It would rather seem, therefore, that if the deep system of veins is occluded, and if the Brodie-Trendelenburg indicates a retrograde flow of blood through the visible varicosities, there must be an intermediate system of collateral veins present to enable blood to escape from the leg. Thus, it would seem that in any case in which a retrograde flow of blood can be demonstrated by the augmented Brodie-Trendelenburg test described above, irrespective of the status of the deep circulation, not only will no harm be done by ligation, but, actually, the usual benefit to the varicose

veins from this treatment should be expected, and even further improvement in the extremity obtained by lessening the load carried by the true collateral circulation. We might add that by eliminating the varicose veins present, one will diminish the tendency for superficial phlebitis (phlebitis migrans) to develop as it so frequently does in patients who have had a deep femoral thrombosis.

It might be mentioned in further support of this theory, that simultaneous ligations of both the superficial and deep venous systems are routinely done by

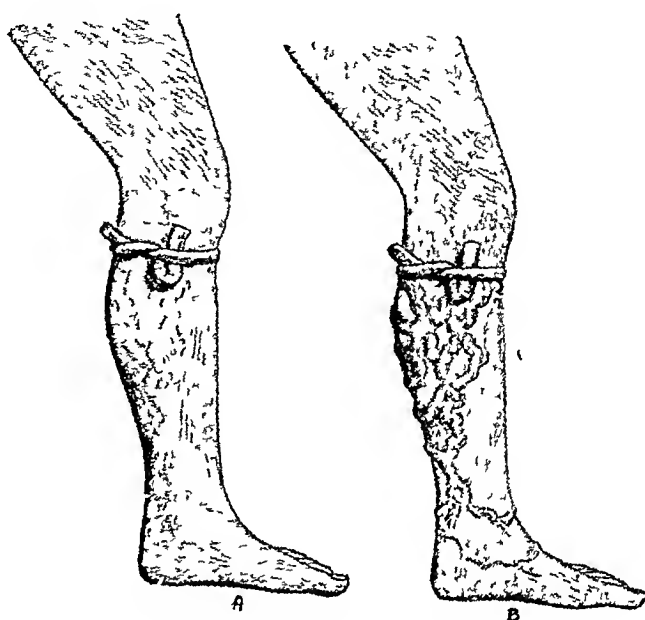


FIG 5—STEP III *Tourniquet Below Knee*

(A) Varicosities collapsed because incompetency exists at entrance of short saphenous into the popliteal above level of tourniquet

(B) Varicosities distended because incompetent communicating veins exist below level of tourniquet

many of us in the active treatment of phlebothrombosis with no untoward results. Furthermore, in phlebothrombosis, one is dealing with veins which were essentially normal until the thrombosis occurred, that is, no time-interval for the development of a collateral circulation existed as it does in the case of chronic deep vein thrombosis.

SUGGESTED APPROACH TO DIAGNOSIS

When the new patient appears for examination, the usual history and physical examination are done. A diagnosis of varicose veins having been established, the following procedure is suggested:

Step I The Brodie-Trendelenburg test is performed, after which one should know the status of the valves of the saphenofemoral junction as well as the existence of any communicating veins below this level.

If the *Brodie-Trendelenburg test* is negative (Fig 1), indicating that the valves of the saphenofemoral junction are intact, but that one or more incompetent communicating veins exist below the level of the tourniquet, the next step is performed

Step II The *Brodie-Trendelenburg test* is repeated with the tourniquet applied just above the knee instead of at the saphenofemoral junction (Fig 4) If the varicosities remain collapsed, one may assume that all incompetent communicating veins lie above the level of the tourniquet, and ligation of the saphenous just above the knee is indicated It has been our experience that ligation here, without a ligation of the saphenous at the saphenofemoral junction, does not produce a complete nor permanent result, and in such cases it has been our custom to perform a high ligation of the saphenous, with its branches in addition As was stated in the discussion of the Mahorner-Ochsner test, "the segment of dilated vein in the thigh extending from the incompetent communicating vein to the level of the low ligation can nearly always be satisfactorily obliterated by subsequent injection therapy In the occasional case where such a varicosity would seem to persist ligation of that communicating vein might be advisable" This is accomplished by marking the uppermost portion of the dilated segment and making a vertical incision through which the dilated vein is dissected upward to the site of the communicating vein which is then ligated and the dilated segment itself is excised

If, on the other hand, the varicosities fill as rapidly as before the application of the lower tourniquet, one of two possible causes exists (1) A retrograde flow of blood may take place from the popliteal vein to the external saphenous, or (2) a retrograde flow of blood may pass from the deep to the superficial veins of the calf through the communicating veins of the lower leg In either event, one further step is then indicated

Step III The *Brodie-Trendelenburg test* is again repeated, this time with the tourniquet just below the level of the entrance of the external saphenous vein into the popliteal vein (Fig 5) If the veins now remain collapsed with the tourniquet in place, one may assume that a valvular incompetency exists at the entrance of the short (external) saphenous into the popliteal, and ligation should be performed at this point Should the veins, however, fill as rapidly as before, one assumes that the incompetency exists in the communicating veins of the lower leg and injection therapy alone will produce a satisfactory result in nearly every instance Here again, if a dilated vein should persist after several injections, local excision of this vein and ligation of the communicating vein through a vertical incision can easily be done

If the *Brodie-Trendelenburg test* is positive at the saphenofemoral junction (Fig 2), indicating incompetency of the valves at this site, one immediately knows that high ligation alone is indicated Occasionally a few supplementary injections may be necessary if any residual varicosities exist when this has been done

If the *Brodie-Trendelenburg test* is doubly-positive (Fig 3), indicating an incompetency of the valves both at the saphenofemoral junction and in the communicating veins below this level, one knows at once that high ligation is indicated, but Step II, and possibly Step III, will be required to disclose the type of supplementary therapy necessary The performance and interpretation of these steps has been described under "negative *Brodie-Trendelenburg test*"

Since we have shown above that there is no need to determine the status of the deep circulation, the clinical examination of the varicose vein patient is completed at this point However, there are occasional cases where actual roentgenographic visualization of the veins of the leg is necessary to arrive at the proper plan of therapy We have found venographic studies to be helpful in the following instances 1 Where swelling, induration and obesity have rendered certain features of the clinical examination inconclusive 2 Where patients have responded poorly to adequate therapy, venograms have occa-

sionally demonstrated an undetected incompetent communicating vein, or an anomalous saphenous vein

SUMMARY

I From teaching experience, as well as from contact with the practicing physician, it is evident that much confusion exists with respect to the diagnostic procedures which have been described in the treatment of varicose veins. Since the institution of appropriate therapy depends entirely upon an accurate diagnosis, this phase of the subject is particularly important.

II A reevaluation of the five tests commonly described in every treatise on this subject reveals that three of them, namely the Perthes', compression, and Schwartz tests, have become obsolete and should be discarded from future use. A fourth test, the Mahorner-Ochsner (comparative tourniquet test), while affording quite complete information about the status of the superficial and deep circulations of the leg, is somewhat complicated, and the information revealed is of largely academic interest.

III The importance of determining the patency of the deep venous circulation in the treatment of varicose veins has been overemphasized, and the complicated tests described to elicit this information have added much to the confusion of the examiner. It is our belief, that irrespective of the status of the deep circulation, if true varicose veins are present, they should be treated as such.

IV A simplified approach to diagnosis, which requires little special knowledge, and which may readily be performed as a simple office procedure, is described.

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Upper Darby National Bank Bldg
Upper Darby, Pa

GIANT INTRACANALICULAR FIBRO-ADENOMA OF THE BREAST

Report of a Case

JAMES C CLARKE, M D.

LA GRANGE, ILL

FROM THE DEPARTMENT OF SURGERY THE MCNEAL MEMORIAL HOSPITAL BERWYN ILLINOIS

ADVANCED CASES OF INTRACANALICULAR FIBRO-ADENOMA of the breast present a bulky, freely movable, encapsulated, nodulated, often ulcerated and fungating tumor In 1827, Cumin¹ reported the first case recorded in medical literature of a large breast tumor of "firm cystic with intracystic fungoid growths" In 1931 Lee and Pack,⁴ in an exhaustive review of the literature since Cumin's case, collected 105 similar cases and reported four of their own MacKenzie,⁵ in 1935, reported a 24 6 pound "adenofibroma of the breast" Owens and Adams,⁶ 1941, collected 12 more cases from the literature of the preceding decade and added one of their own, bringing the total reported at that time up to 123 As nearly as can be determined from the descriptions of all the reported cases, only 10 of these tumors exceeded in size and weight that of the case reported in this paper

Many names have been given to this type of tumor, each emphasizing one aspect of its protean nature All of these were listed in the report of Owens and Adams⁶ and will not be repeated The consensus of opinion now is that the most accurate terminology is intracanalicular fibro-adenoma, characterized in the late stages by myxomatous degeneration Because of this myxomatous degeneration, these late cases have been called "intracanalicular myxoma and cystosarcoma phyllodes" However, since these tumors are not truly malignant, this nomenclature is misleading Although sarcomatous degeneration may occur, it usually does not, even when the tumor has existed for many years

REPORT OF A CASE

Mrs A C, the patient, was 52 years old, white, married and nulliparous Her mother had had a goitre The family and past history were otherwise irrelevant Upon admission to the hospital, July 19, 1944, her chief complaint was an enormous tumor of the right breast (Figs 1 and 2) Thirteen years ago, she discovered a lump in her right breast, which gradually increased in size, until she could no longer endure it, because of its size and weight Three and one-half years ago the tumor began to ulcerate and exude a bloody serum from the raw surface requiring daily dressings During the past five years she had lost 25 pounds weight and had noticed increasing nervousness Palpitation and insomnia had been present for two years In the past four months marked weakness had developed There had been no diarrhea

Physical examination revealed an anemic, poorly nourished, white female, not acutely ill She was 5 feet 5½ inches tall and weighed 119 pounds Her temperature was 100.2 degrees, pulse 100, and respiratory rate 20 There was no lagophthalmos or exophthalmos and the pupils were equal and reacted to light and accommodation There was a marked diffuse hyperplasia of both lobes and isthmus of the thyroid and a fine tremor of both hands



FIG 2—Lateral view—Note pedunculation of tumor and dilated veins of pedicle, also goitre



FIG 1—Anterior view—Note complete ulceration and bosselation of whole breast, also enormously dilated veins of chest wall

There was an enormous tumor of the right breast, 6 x 9 x 10 inches in diameters. Most of its surface was raw, fungating and nodulated with only a rim of skin around the periphery. It was of solid consistency, very heavy and hung freely on a pedicle of skin. There were no palpable axillary lymph glands. The heart was slightly enlarged, the left border being just outside the midaxillary line. The rhythm was regular. There was a loud systolic aortic murmur. The rate was 100 to 110. Blood pressure was 138/70. The reflexes were hyperactive. There was no edema of the extremities. Physical examination was otherwise negative.



FIG 3—Low power Adeno-fibroma of breast. Glandular, papillary, fibrous structure, secretory in type.

The urine was negative. Hemoglobin was 43.9 per cent or 6.80 Gms. Red cells 3,300,000, leucocytes 8,000, P-72 per cent, L-24 per cent, M-4 per cent. B.M.R. was plus 43 per cent. A roentgen-ray examination revealed a 4 per cent enlargement of the heart and generally increased lung markings. E.K.G.-rhythm was normal. There was evidence of a partial A.V. block, and a left axis deviation. The diagnosis of adeno-fibroma of the right breast, toxic adenoma of the thyroid and arteriosclerotic heart disease, was made.

Four days after admission to the hospital a simple right mastectomy was performed under nitrous oxide and oxygen anesthesia. On the second postoperative day the temperature dropped to normal and remained there. She was then put on ten drops of Lugol's solution t.i.d., p.c. and three capsules of liver and iron q.i.d. and sent home. Three weeks after the mastectomy she returned to the hospital weighing 100 pounds, and a subtotal thyroidectomy was performed.

The pathologic study was made by A. H. Baugher, M.D. The specimen consists of a mass weighing ten pounds and measuring 22 x 21 x 14 centimeters. It is incompletely

FIBRO-ADENOMA OF THE BREAST

surrounded and covered by skin which shows many ulcerating areas. These areas vary in diameters up to seven centimeters, and have the general appearance of a granulating surface. On gross sectioning this tumor mass is found to be composed of numerous nodular, somewhat discreet, masses of tissue. These nodular masses are yellowish-gray, soft, and fibrous. Many hemorrhagic areas are found throughout. These vary in size up to several centimeters in diameter. Necrotic and cystic changes are also found throughout. Grossly, the above structures represent a right breast which has become excessively large, pendulous, and ulcerated. The pedicle measures five centimeters in each diameter and three centimeters in length.

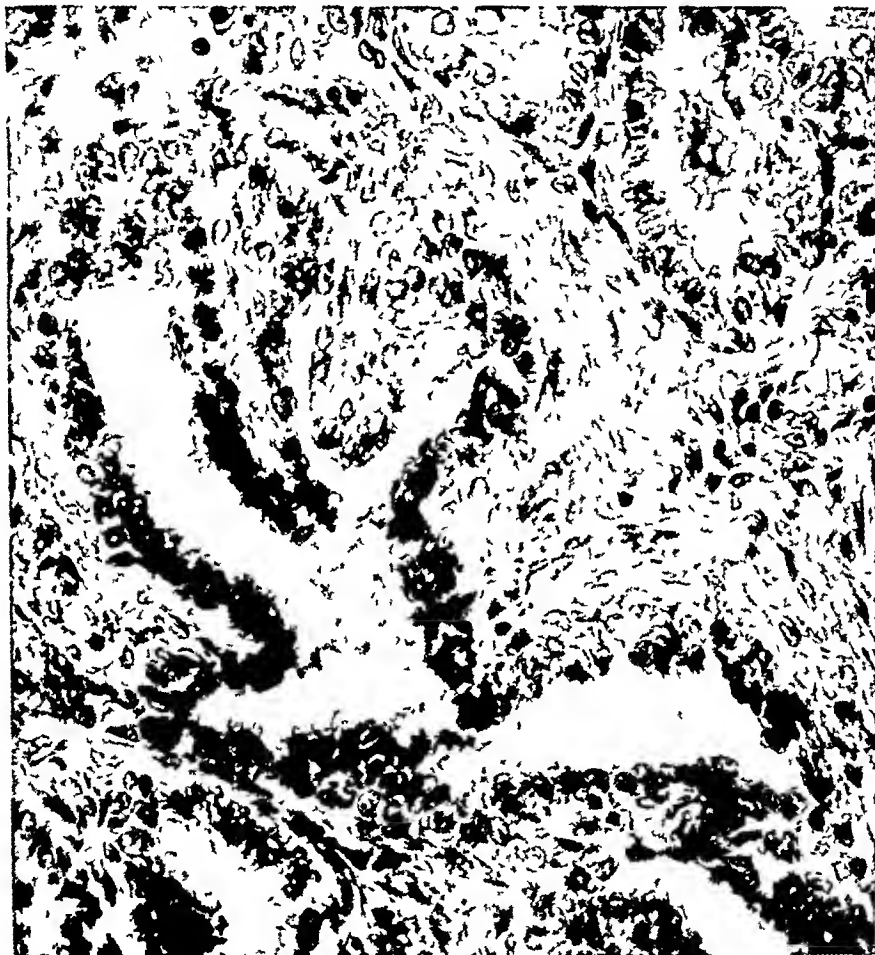


FIG 4—High power Adeno-fibroma of breast (High power of #3) Note colloid of myxomatous degeneration

Histologic sections show a predominant and marked overgrowth of the glandular elements. The stroma also shows marked hyperplasia. The glands are lined by a uniform epithelium which is secretory in type. These epithelial elements frequently show a papillary growth into definite alveoli and distended tubules. The basement membrane is intact. Many of the distended alveoli contain an eosin staining material. The interstitial fibrous connective tissue shows moderate periacinous proliferation and moderate myxomatous degenerative changes. The diagnosis is benign, pendulous, intra- and peri-canalicular adenofibroma of right breast (Figs 3 and 4). Study of the thyroid gland reveals an adenomatous colloid hyperplasia of the thyroid.

Six weeks later the patient's basal metabolic rate was plus 12 per cent and her weight 124 pounds. Seven months after thyroidectomy her weight was 150 pounds, her normal weight. Up to the present time the patient is in good health.

CONCLUSION

1 An unusual case of giant fibro-adenoma of the breast weighing ten pounds is reported

2 There was a concomitant toxic adenoma of the thyroid which masked the picture

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MASSIVE RESECTION OF THE SMALL INTESTINE

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WHEN A SITUATION presents itself, requiring excision of a large segment of small bowel, the "surgeon is confronted with the alternative of allowing the patient to die or resorting to a heroic effort to save the individual by resection"¹ Such cases are never of an elective nature and are encountered so rarely that I quote Holman² to introduce the following report "The following case history may lighten the anxieties of other surgeons who may have to undertake resection on a heroic scale. At the time of operation imperfect acquaintance with the published work led me to take a gloomy view of the patient's prospects."

CASE REPORT

Mrs. H. C., a female, age 48, entered the hospital on July 7, 1946, in shock complaining of severe pain in the epigastrium which radiated to the back.

The patient had been under treatment for rheumatic heart disease for the past several years and had been confined to bed for most of the time during the past year. For this reason she had recently come to Arizona. Four days before admission the patient had noted epigastric distress with abdominal cramping and diarrhea. On the morning of entrance to the hospital the patient had a sudden attack of severe pain in the epigastrium followed by nausea, vomiting and collapse. When seen by her physician, Dr. Norman Jacobson, she had a blood pressure of 60/40, respiration 32, a pulse rate of 140 and was pale and perspiring. Both lungs were moist, with rales in the bases. Sinus arrhythmia, enlargement of the heart to the left, and a loud systolic and diastolic murmur at the apex was present. The abdomen was distended with marked tenderness over the epigastrium. Bowel sounds were absent. No fluid level could be ballotted or percussed. No involuntary rigidity was present. Rectal and pelvic examinations revealed no abnormalities.

Serum amylase was 17 mgs (normal 20-40 mgs). RBC 4,870,000, Hb 15 Gm, WBC 10,960, Stab 14, Seg 59, Lymph 27, Urine (Voided) albumin 2 plus, leucocytes 2-4, erythrocytes, neg.

Roentgenograms of chest "Suggest old rheumatic heart with left auricular enlargement." Roentgenogram of abdomen—"Liver moderately enlarged, distention of major portion of small bowel. No free air in abdomen."

Clinical Diagnosis Mesenteric thrombosis

Operation Under general anesthesia left paramedian incision was made, and on opening the peritoneal cavity a moderate amount of "port wine colored" fluid was found, having a putrid odor. Most of the small intestine was found to be gangrenous. There was no evidence of spillage from the bowel, but there was a good deal of the bloody serous material present in the cul-de-sac. For 14 inches from the ligament of Treitz the jejunum appeared viable. The bowel was then traced distally toward the cecum, and it was found that there was no further viable bowel remaining to the cecum, the cecum itself was discolored and there was some question about whether its circulation was ample. Resection of the entire small intestine with exception of about 14 inches of the jejunum and

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the duodenum was done. The intestine was resected up to the cecum and this area was inverted with three layers of sutures. The portion of the jejunum remaining was then brought to the ascending colon and an end-to-side anastomosis made, using three layers of sutures. The mesentery was tied with #1 plain catgut. The patient withstood this rather well, her condition being maintained by intravenous blood during the operation. The abdomen was closed in layers. One penrose drain was left in the subcutaneous tissue.

Post Operative Diagnosis Arterial embolism of the superior mesenteric artery with gangrene of the greater portion of the small intestine.

Pathologic Report Gross. Specimen consists of a portion of small intestine 310 cm in length. Much of the intestine and attached mesentery are very dark in color, giving the appearance of beginning gangrene. The small blood vessels are filled with blood clot.

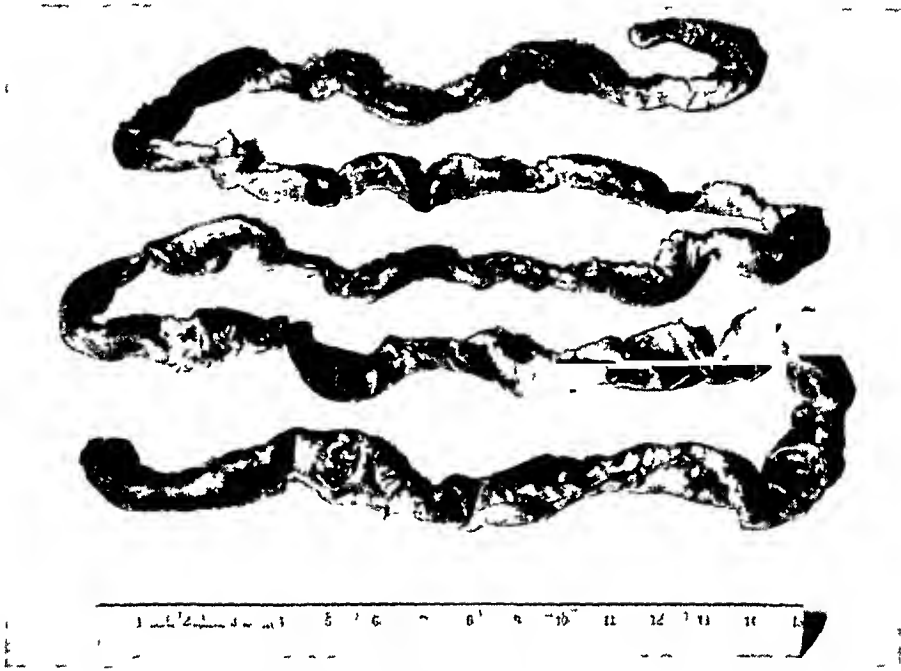


FIG 1—Photograph showing the intestine removed at operation

Microscopic There is marked extravasation of blood into the tissue of the mesentery. Small blood vessels are filled with organized blood clot.

Diagnosis Mesenteric thrombosis

Wangensteen nasal suction, constant O₂, intravenous fluids, transfusions, digifolin and penicillin 20,000 units every three hours were begun. Heparin was instituted on the first postoperative day with exercises on pedals. Nasal suction was discontinued on 7-12-46, on which day she passed several liquid stools. The temperature varied from 99 to 102 degrees the first week, then declined to normal. On 7-14-46 the patient had moderate bleeding from her incision and heparin was discontinued. On 7-15-46, the blood cholesterol was 118 mg/100 cc (Normal 150-200 mg/100 cc). The patient was given a high protein, low fat diet and had from four to eight liquid, foul stools daily. On 7-26-46 it was observed that the patient had mild carpopedal spasm. On the same day the blood calcium was 7.7 mg per 100 cc, a plasma protein was 7 Gm per 100 cc, and a glucose tolerance test was normal. Calcium gluconate with viosterol was instituted with rapid subsidence of the carpopedal spasms. Ambulation was started on 7-16-46. The patient was discharged from the hospital on 7-31-46, having four to six liquid bowel movements daily.

RESECTION OF SMALL INTESTINE

The patient gained strength and returned to her home in Ohio in September 1946. A letter dated January 20, 1947, from the daughter who is a graduate nurse, states "The patient has been in the hospital three times since leaving Tucson. Her first visit was in October with the diagnosis of acute myocardial failure. Three weeks later with acute myocardial failure, pneumonia and pulmonary edema. Her third trip was last week for four days. I don't know what the last diagnosis was, but she coughed a lot and expectorated a lot of frothy bright red blood for the first two days. Between visits to the hospital she had been out of bed, knitting, etc. She weighs between 95 and 100 pounds.



FIG 2—Postoperative x-ray film, taken on July 30, 1946, showing length of small intestine remaining. The film is retouched for clarity. Due to rapid passage of barium it was necessary to superimpose another film to determine the exact outline before retouching.

Her appetite is excellent. She eats every four or five hours when awake. She has a partially formed stool each morning and about four hours after each meal, the latter stools are loose and frothy in appearance."

COMMENT

The term "massive" when applied to resection of the small bowel is indicative that the amount of intestine removed measures 200 cm or more. The majority of reports on this subject which have appeared in the literature have

emphasized the amount of intestine removed. Little or no mention has been made as to the amount of bowel remaining to carry on the absorption and digestion for maintaining nutrition, yet this is the most important factor to be considered. This omission becomes more obvious when it is considered that the small bowel varies considerably between the races, the individual's diet, and the sexes. Bryant³ found that the small intestine's length varied from 10 feet (304 cm) to 28 feet 4 inches (863 cm) in adults. It is shorter in women than in men and relatively longer in children. The Japanese and Russians, who eat coarse foods have longer intestines than races eating meats and more refined foods.

There are many reports of massive resection reported, beginning with Koeberle in 1880, with recovery of the patient (quoted from Haymond). Haymond made a thorough review of 257 cases of massive resection and found that the mortality was 33.5 per cent but concluded that this did not represent the true mortality because of the tendency to report only the successful cases. He concluded after studying these cases that a patient can withstand a resection of 33 per cent of the length of the small intestine with the expectation that the digestive tract will return to normal function, 50 per cent removal constitutes the upper limit of safety in extensive enterectomy and resection of more than 50 per cent must necessarily yield poorer results even though an exceptional case may do better than predicted. Sarnoff⁴ states that the removal of 80 per cent proves fatal. In the case herein reported about 80 per cent of the small bowel was resected with survival.

The small intestine is the chief portion of the alimentary tract from which food stuffs are absorbed. No significant absorption occurs in the colon. The jejunum absorbs more fluid and sugars and the ileum absorbs the major portion of the digested proteins and fats. When a large segment of small bowel is removed compensation takes place in several ways. Flint⁵ performed long enterectomies on dogs and found that the remaining portion did not grow in length but increased in diameter to twice the previous size. There was no regeneration in the crypts or villi, but an increase of 400 per cent in the absorbing surface was found. The villi are more numerous in the duodenum and jejunum, and in these regions the absorption rate is also the greatest. The surface area of the intestine, averaging one half square meter, is increased almost to 10 meters by means of these projections.⁶ It is stated by Sarnoff that compensation for resection of the ileum is aided by an increase in gastric secretion, and gastric digestion lasts two hours longer. In our case 50 per cent of the barium was retained in the stomach after the remainder of the barium meal had advanced as far as the sigmoid. Wildegans⁷ found that fats and proteins were not well digested during the first four weeks in dogs after resection of two-thirds of the intestine, but that the animals later regained this ability to a certain extent.

Metabolic studies were made by West et al^{8, 9} of a man with all but three feet of small intestine resected. It was observed that carbohydrates were as well utilized as in normal individuals, 75 per cent of the protein and 55 per

cent of the fat were metabolized. The fecal fat consisted of 80 per cent fatty acids which indicated a good degree of digestion, but a considerable part of this may have occurred after the fat had reached the large intestine in which case it wouldn't have been absorbed. When a high fat diet was given, only 38 per cent of the fat was utilized and the patient developed a negative calcium balance manifested by tetany and a low blood calcium. The large amount of free fatty acids in the stool apparently carried the calcium away in the form of a calcium soap. It seems unlikely that these soaps would be absorbed except in the lower intestine since a significant degree of saponification would not occur in the usually acid contents of the duodenum and upper jejunum. Cosh¹⁰ recorded a case of massive resection with achlorhydria who later developed tetany. He believed the anacidity was an important factor since the absorption of calcium which occurs primarily as calcium chloride in the upper intestinal tract is favored by an acid medium. West et al, noted a negative phosphorus balance in their patient, this could be accounted for on the basis of poor calcium absorption. On a high carbohydrate, low fat diet and a high calcium and vitamin D intake the phosphorus and calcium were brought into positive balance. In a case studied by Dragstedt, described by Haymond,¹ with only 55 cm of small intestine functioning, it was found that a normal chloride balance was maintained. In our case a low blood cholesterol was present which was probably related to the inefficient lipid absorption. No reports have been found which compared the absorption and digestion within retained segments of ileum with those in which only jejunum remained intact. The greatest number of reports available for study neglected to state which portion of the small intestine remained after resection and this is an important factor in prognosis. A higher percentage of patients should show inanition if the upper segments (jejunum and/or duodenum) are removed than if the lower segments are resected. It is logical to assume that resection of the ileum is more often demanded than that of the upper small intestine. The lower bowel is much more liable to become involved in a volvulus (the most frequent reason for massive resection) and the same portion of intestine is more frequently affected by arterial emboli due to the fact that it receives its blood supply from the lower portion of the superior mesenteric artery where emboli are more likely to lodge. Other factors affecting prognosis are the length of the bowel remaining, its degree of compensatory reaction, the disease which necessitated its removal and the resistance of the patient.¹¹⁻¹² Inadequate compensatory changes following massive resection of the small bowel result in a loss of weight, anemia, diarrhea, edema, tetany, weakness (potassium loss?) and possible vitamin deficiencies.

SUMMARY

A case of massive resection of the small intestine has been reviewed, in which no more than fourteen inches (35 cm) of the jejunum was left remaining, with survival of the patient. She has manifested the same symptoms and findings as other such reported cases, namely poor fat digestion with frequent

fatty stools, associated low cholesterol and deficient calcium absorption. The carbohydrates and proteins were well metabolized. There was good response postoperatively on a high protein, high carbohydrate, low fat diet augmented by oral calcium and vitamin D.

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BOOK REVIEW

COLOR ATLAS OF HEMATOLOGY

By Roy D. Kracke, M.D., Dean of the Medical College of Alabama 204 pages and 107 illustrations including 32 color plates J. B. Lippincott Company, Philadelphia, \$6.00

THIS BOOK WAS INTENDED by the author to supply the need for a color atlas of hematology for the use of medical students, laboratory workers and general practitioners of medicine. The first 16 pages are occupied with definitions of hematological terms. Some of the definitions are needlessly restrictive. *Oxygen tension* is defined as applying to the bone marrow, photometer as an instrument to measure the amount of hemoglobin. Others (like the Van den Bergh reaction) tell the purpose of the test without defining the reaction itself. This section is followed by a brief consideration of the origin and development of blood cells and a description of the morphology of the cells themselves accompanied by clear, well spaced out, colored drawings, paired with diagrams for the identification of each cell.

Other chapters deal with the hematologic appearance of various blood disorders (anemias, leukemias). Plate #17 illustrates the appearance of the blood in hemolytic jaundice but fails to delineate the presence of spherocytes, though they are alluded to in the explanatory text. Dohle bodies, not uncommonly seen in septicemias, are not mentioned anywhere, though one polymorphonuclear leukocyte containing them may be found in plate #14. Auer bodies are not mentioned or illustrated. The later chapters of this useful manual deal with the technic of various hematological determinations, an illustrated discussion of common blood parasites, and the appearance of the blood cells of certain common laboratory animals. The book fulfills rather well its chief purpose, namely, to supply pictorial and descriptive information for the guidance of workers in this field.

LEANDRO M. TOCANTINS

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ANNALS OF SURGERY
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COMPLETE TRANSPOSITION OF THE AORTA AND THE PULMONARY ARTERY¹

Experimental Observations on Venous Shunts as Collective Procedures

C ROLLINS HANLON, M D, AND ALFRED BLALOCK, M D

BALTIMORE, MD

FROM THE DEPARTMENT OF SURGERY OF THE JOHNS HOPKINS UNIVERSITY
AND THE JOHNS HOPKINS HOSPITAL

COMPLETE TRANSPOSITION of the aorta and the pulmonary artery is an infrequently encountered condition^{1, 13, 15, 16} which may be diagnosed with fair accuracy during life¹⁷. Recent progress in the surgical therapy of other types of congenital heart disease has prompted us to approach the problem of transposition in a similar fashion. We shall discuss some possible modes of surgical attack on transposition of the great vessels after a brief review of its pathologic anatomy and physiology.

The pathogenesis of transposition is still not wholly clear despite intensive study of the problem for more than a century. A number of ingenious and conflicting theories have been adduced, none of which is completely satisfactory, and the accompanying differences in terminology have further confused the issue. For a critical review of the subject one may consult the recent papers of Harris and Fairber⁶ and Lev and Saphir¹⁰.

In complete ("uncorrected") transposition of the great vessels the aorta arises from the ventricle receiving systemic venous blood and the pulmonary artery arises from the ventricle receiving oxygenated blood. Blood pumped out by the left ventricle through the pulmonary artery to the lungs returns through the pulmonary veins and left atricle to its point of origin, the right ventricular blood emerges through the aorta and proceeds in a similarly closed circuit through the systemic circulation. The greater and lesser circulations are thus basically separate, a condition obviously incompatible with continued existence. In most instances, however, some degree of communication exists between the two circulations by way of septal defects or other abnormalities. These compensating abnormalities send some oxygenated blood through the systemic circulation, thus permitting the patients to survive for variable periods.

"Transposition" in pure form consists merely of a posterior origin of the pulmonary artery that goes directly back to the lungs, whereas the aorta arises anteriorly and escapes its usual encirclement by the pulmonary artery. If the ventricles are similarly reversed in position no physiologic abnormality

* Aided by a grant from The Carolyn Rose Strauss Foundation, Monroe, Louisiana

is evident and the transposition is "corrected" But if the pulmonary artery arises from the ventricle receiving oxygenated pulmonary blood and the aorta from the ventricle receiving systemic venous blood, the transposition is termed "complete," "uncorrected," or "transpositio vera" It is this latter condition which we shall discuss

The term "uncorrected" was adopted presumably to indicate that the abnormal position of the great vessels was not "corrected" by a similar change in the position of the ventricles It is a poor term, however, since it suggests that no other compensatory abnormality is present, such as interatrial or interventricular septal defects One must realize, however, that every patient with "uncorrected" transposition who survives beyond fetal life has additional abnormalities tending to correct the lack of mixing between the two circulations Because of this confusion we favor the term "complete transposition" ("transpositio vera")

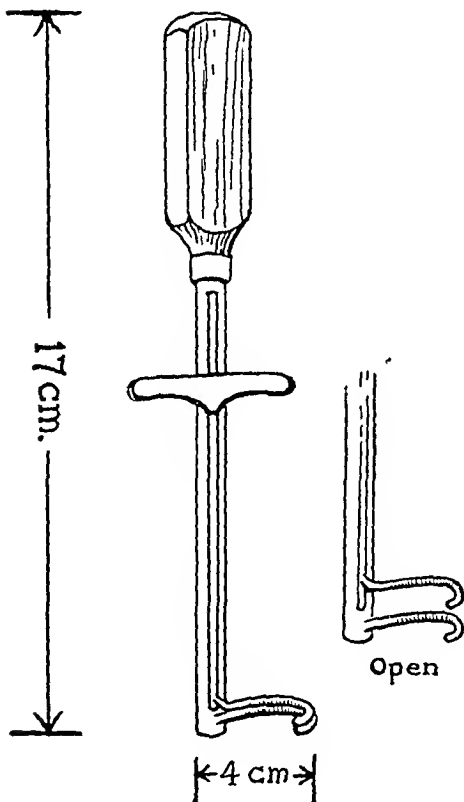


FIG 1—Special clamp for end-to-side anastomosis

For a patient with complete transposition to survive after birth there must be a means by which oxygenated blood reaches the aorta This may be effected by way of an interatrial or interventricular septal defect, by a patent ductus arteriosus, or by passage of pulmonary venous blood into either vena cava Such abnormalities in various combinations provide a degree of compensation which in rare instances has resulted in prolonged and fairly normal existence

The literature on this point has been surveyed by Kato,⁸ who collected 92 cases of transpositio vera and added five of his own In 85 of these 97 cases the data are sufficient for analysis At least 15 cases have since been reported by others,^{5, 6, 10, 11, 12, 14, 16, 18} and we include an additional 23 studied at autopsy in The Johns Hopkins Hospital to make a total of 123 complete transpositions

Of Kato's 85 cases, 70 died in less than a year In those with complete

transposition and an atrial septal defect the survival time averaged over two years, while in those with transposition and a ventricular septal defect the average age at death was well over four years The combination of interatrial and interventricular septal defects gave an average survival time of five and one-half years in 16 cases It should be noted that the inclusion of two individuals aged 19 and 56 years lends an unduly favorable character to the

average survival time for the group with combined defects. Without this long-surviving pair the average life span of the group would be less than a year. Long survivals are of course quite likely to be reported individually in the literature, while stillbirths or neonatal mortalities are included only in large series or not reported at all.

In the 123 collected cases the average duration of life was nineteen months. Six patients lived ten years or longer, if these are excluded, the average duration of life for 117 patients is only five and one-half months. The survival time of patients with complete transposition and various associated abnormalities is seen in the following table.

TABLE I—*Complete Transposition
Duration of Life with Various Associated Abnormalities*

Associated Abnormality	No. of Cases	Duration of Life
Patent foramen ovale*.	13	1 yr 11 mo
Patent ductus arteriosus	12	64 days
Patent foramen ovale plus ductus arteriosus	44	40 days
Interventricular septal defect	12	4 yrs 1 mo
Patent foramen ovale plus interventricular septal defect	19	4 yrs 9 mo
Patent ductus arteriosus plus interventricular septal defect	7	2 yrs 3 mo
Patent foramen ovale and ductus arteriosus plus interventricular septal defect	16	5 mo
Total	123	Average duration—19 mo

* Indicates any interatrial septal defect.

It is apparent that in complete transposition an interventricular septal defect is the single compensating abnormality associated with the largest life expectancy. A patent interatrial septum is the next most favorable isolated defect, and the combination of these two gives the best prognosis of all.

As a result of these defects some oxygenated blood passes into the aorta. A similar result may occur when pulmonary veins empty into the systemic venous auricle or into either vena cava.

Surgical therapy for transposition of the great vessels might reproduce any of the defects mentioned above. Interventricular defects have been produced experimentally for many years, but it is difficult to control the size of the defect, and a blind approach through the ventricular wall makes the procedure both uncertain and hazardous. Further developments in the technic of intracardiac manipulation under cardioscopic control may alter this aspect of the problem, but our current discussion is limited to experimental procedures carried out under direct vision.

Having excluded interventricular septal defects and leaving the technic of producing interatrial defects and other procedures to subsequent communications, we may consider the artificial production of pulmonary venous return to the right side of the heart. This condition is found occasionally at autopsy in patients who have shown no symptoms of cardiovascular abnormality. The number of pulmonary veins entering the right side varies from one vein up to

all the veins, a condition which is found in about a third of these individuals. The subject has been well reviewed by Brody,¹ and the surgical significance of anomalous pulmonary veins has recently been stressed by Brantigan.² This author mentions the possibility of transferring aberrant pulmonary veins from the right atrium or its tributaries into the left atrium. In the present studies we are concerned with a directly opposite procedure, namely, the anastomosis of pulmonary veins to the right atrium or its tributaries.

Such a venous shunt would bring oxygenated blood to the right side of the heart. To test the effect of this on an experimental transposition, one must first produce the corrective shunt and subsequently produce the transposition, if the sequence of the procedures were reversed the animal could not possibly survive. In a number of attempts, which are being continued, we have not yet succeeded in producing a complete transposition of the aorta and the pulmonary artery in the dog. Therefore our observations are confined to (1) anastomoses of the pulmonary veins to the right auricle, and (2) anastomoses of the pulmonary veins to the superior vena cava.

METHODS AND PROCEDURES

Healthy adult mongrel dogs were used, varying in weight from 60 to 200 kg. The average weight was 106 kg. After premedication with morphine sulfate ($\frac{1}{4}$ to $\frac{1}{2}$ gr) and $\frac{1}{150}$ gr of atropine sulfate they were anesthetized by drop ether followed by introduction of an endotracheal catheter with inflatable cuff. A mechanical device provided regular periodic inflation of the lungs with ether vapor while the chest was open. An intercostal approach through the right fourth interspace afforded adequate exposure in all cases. At the conclusion of the procedure the ribs were approximated by absorbable pericostal sutures and air was evacuated from the pleural cavity before closure of the skin by means of an intercostal catheter. All wounds were closed in layers with fine silk.

In both groups of animals we used a special occlusive clamp which allowed bloodless access to one portion of the heart and veins while permitting a relatively free flow of blood in their remaining portions. This clamp (Fig 1) consists essentially of two semicircular jaws of rounded wire, the upper one sliding in a grooved handle and capable of exerting pressure against the lower, fixed jaw by means of a spring.

I Anastomosis of Pulmonary Veins to the Right Auricle

The veins from the apical and cardiac lobes of the right lung are isolated and divided after ligation at their point of entry into the left auricle. This involves sharp dissection in the plane between the ventral wall of the pulmonary veins and the adherent dorsal wall of the right auricle. It is usually necessary to free the veins for a full centimeter medial to their point of attachment to the right auricle. This allows one to work with a good length of common pulmonary vein. Backflow is prevented by bulldog clamps on the tributary veins from the two lobes.

TRANSPOSITION OF THE AORTA

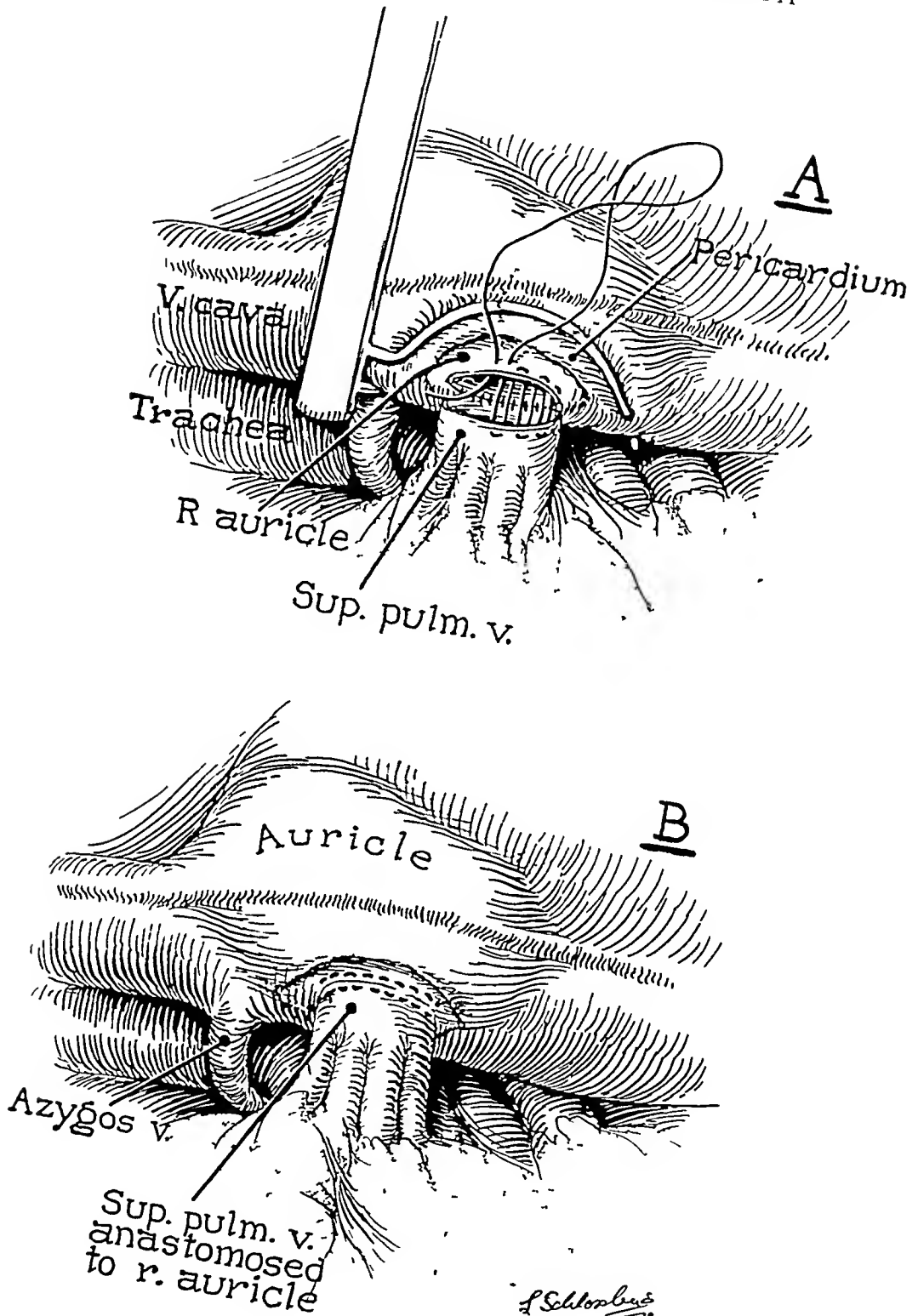


FIG. 2—(A) With occlusive clamp preventing bleeding from the right auricle, a circular anastomosis is being made between the superior pulmonary veins and the right auricle. Bulldog clamps preventing backflow from the lung are omitted from the drawings for the sake of clarity.
(B) Completed anastomosis

The pericardium is reflected from the right auricle and the spring clamp is applied to the ventral and lateral aspect of the auricle, thus isolating a crescentic segment. This portion of the auricle is seen externally as the point of junction between the two cavae, from which it differs little in gross appearance (Fig 2A). Histologically, however, it is seen to resemble auricular musculature, without the characteristic trabeculations. An elliptical portion of the auricle is excised with scissors to give an opening comparable in size to the lumen of the superior pulmonary veins, usually 10 to 15 mm in diameter. Into this auricular opening the superior pulmonary veins are implanted by a running mattress suture which everts the intima and is interrupted at several points by everting mattress stay sutures (Fig 2B). On removal of the clamp there may be a temporary oozing of blood along the suture line, readily controlled by a short period of light pressure. Additional sutures are seldom required. A few fine sutures close the pericardium over the anastomosis. The branches of the pulmonary artery to the upper lobes are occluded during the performance of this anastomosis as well as in the procedure described below.

II Anastomosis of Pulmonary Veins to the Superior Vena Cava

This procedure closely resembles the one just described, except that the veins are implanted into a defect formed by excision of the azygos vein at its point of entry into the superior vena cava. It is usually necessary to free the pericardium from the vena cava and to expose the vessel thoroughly before application of the spring clamp. With the clamp in place there need be no impairment of venous return to the right auricle by way of the superior vena cava (Fig 3A). The azygos vein and a circular segment of the wall of the vena cava are excised with scissors, giving an opening comparable in size to that of the pulmonary veins. A circular anastomosis is carried out as previously described, and the clamp is removed, allowing entry of oxygenated blood to the right auricle by way of the superior vena cava (Fig 3B).

RESULTS

All of the operative procedures were well tolerated, except for one death due to anesthesia. At varying periods after operation the patency of the anastomosis was investigated by angiocardiology or by direct catheterization of the right superior pulmonary veins through the jugular vein.

The animals were killed under anesthesia at intervals up to one hundred and one days. In some instances the condition of the anastomosis was investigated roentgenologically after injection of Hill's mass, and in nearly all cases the autopsy included microscopic examination as well as gross study.

Pulmonary Veins Into Auricle In ten instances the pulmonary veins from the upper lobes of the right lung were anastomosed into the right auricle by the technic described. There were no operative deaths. Physiologic studies demonstrated the patency of the anastomosis in some cases, when patency could not be shown, autopsy usually confirmed the obliteration

TRANSPOSITION OF THE AORTA

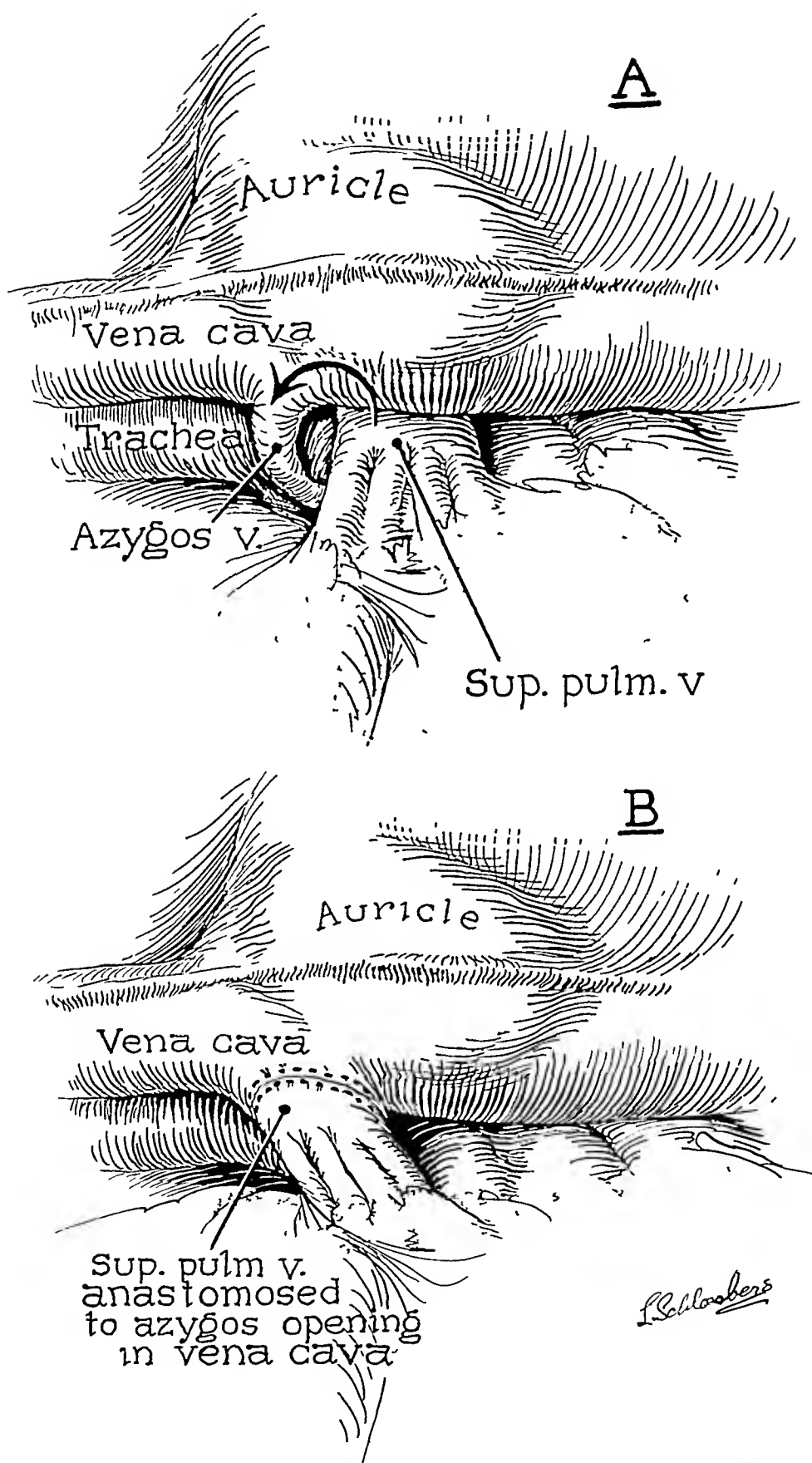


FIG 3—(A) Arrow indicates proposed anastomosis of the superior pulmonary veins to the defect left by excision of a segment of superior vena cava at the azygos opening

(B) Completed anastomosis

of the stoma. In some instances marked constriction of the stoma rendered catheterization impossible, even though an opening several millimeters in diameter remained.

When difficulty had been encountered in catheterization of the pulmonary vein one commonly saw subendocardial hemorrhages in the auricle at autopsy. This observation suggested that vigorous attempts at catheterization might

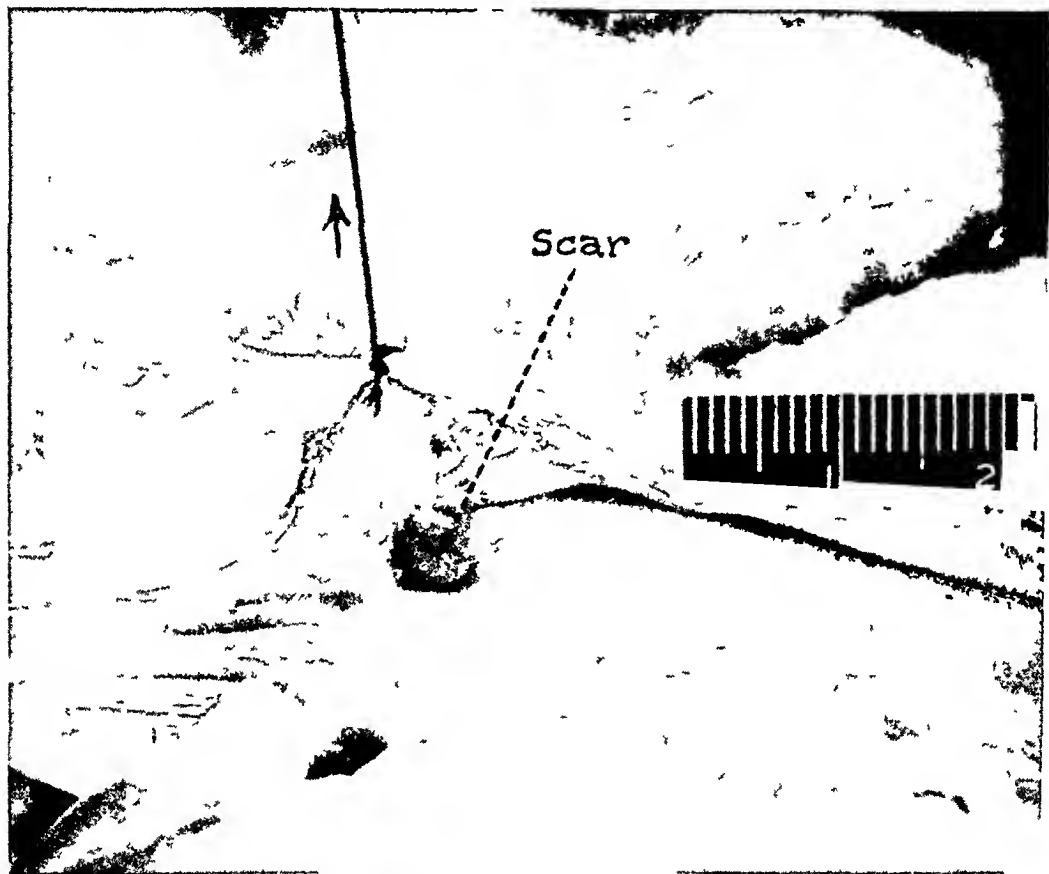


FIG. 4—Right auricle opened to show hyperplastic scar at the site of an unsuccessful anastomosis.

contribute to closure of the stoma by scarring. The site of an obliterated anastomosis was generally represented by a hyperplastic scar, quite readily detected during life by palpation with the rigid cannula passed through the jugular vein. The appearance of such a scar may be seen in the accompanying photograph (Fig. 4).

In contrast to the appearance in Figure 4 is the appearance of a successful result shown in Figure 5. One may see the smoothly healed, oval anastomosis as well as the openings of the pulmonary veins. The microscopic appearance of the junction of the thin-walled veins with the relatively thick auricular muscle is seen in Figure 6.

TRANSPOSITION OF THE AORTA

Results were evaluated by gross and microscopic examination of the operative site from 26 to 101 days after operation. Four of the results were satisfactory, six were unsatisfactory. In three instances the anastomosis was widely patent, in one there was some constriction of the opening, in three the constriction was quite pronounced, and three were totally occluded.

Technical difficulties were encountered while the procedure was being developed, and it was in these early experiments that the unsatisfactory results were largely obtained. It must be noted, however, that even in the final operation in this series some constriction of the anastomosis was found

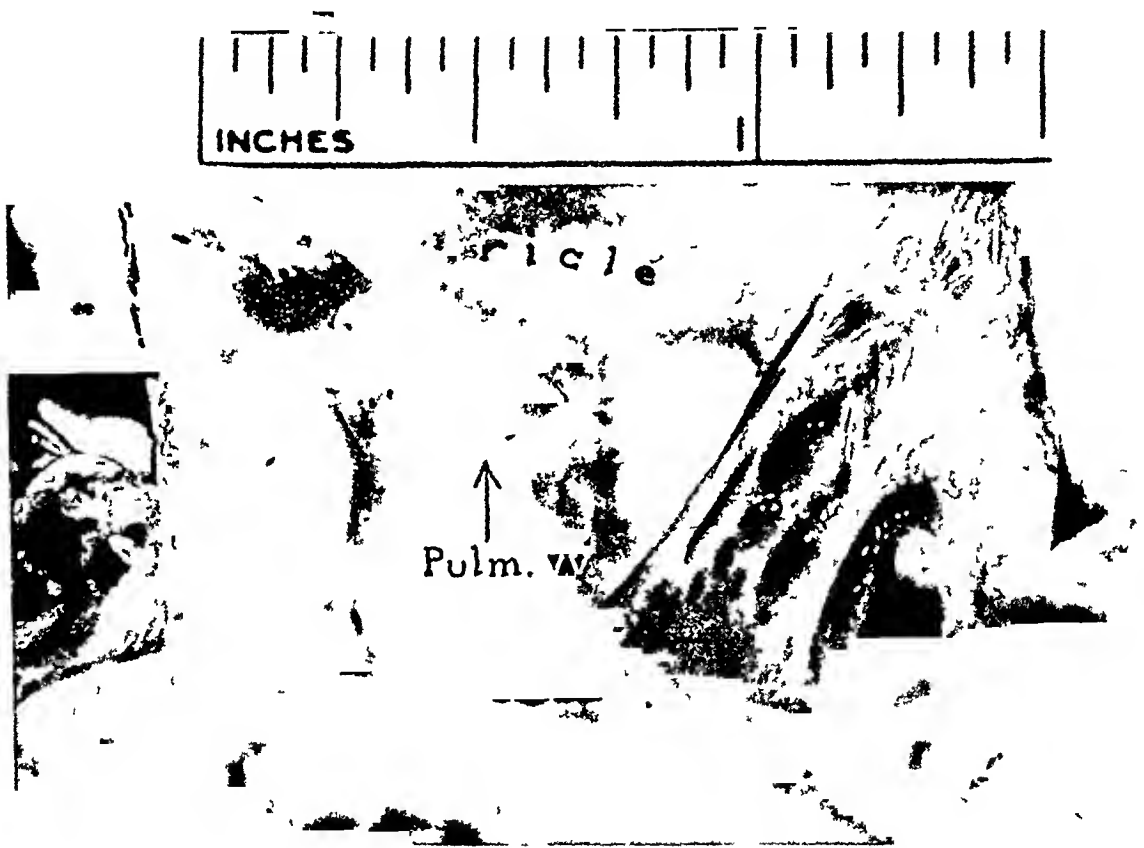


FIG 5—Excellent result 26 days after anastomosis of superior pulmonary veins to the right auricle. The openings of the tributary veins are well demonstrated.

at autopsy. This finding suggests that technical difficulties are inherent in the operation, and it seems likely that the thick auricular wall, especially in its trabeculated area, is not well suited to vascular anastomosis.

Pulmonary Veins to Superior Vena Cava The pulmonary veins were anastomosed to the superior vena cava at the azygos opening in 15 animals. There were no deaths during the operative procedure. Two animals died of infection, four and eight days after operation. These two anastomoses were widely patent at the time of death, but of course insufficient time had elapsed to evaluate the result.

In the remaining 13 dogs there were 10 excellent results, two with a patent but constricted anastomosis, and one in which the anastomosis was totally occluded

In all three preparations showing poor results some technical mishap occurred during the performance of the anastomosis. In one instance a suture placed to control a tear in the pulmonary vein had completely occluded the anastomosis.

The gross and microscopic picture in a case that healed well may be seen in the accompanying illustrations. The site of anastomosis is viewed from the interior of the superior vena cava in a dog killed after 83 days (Fig 7)

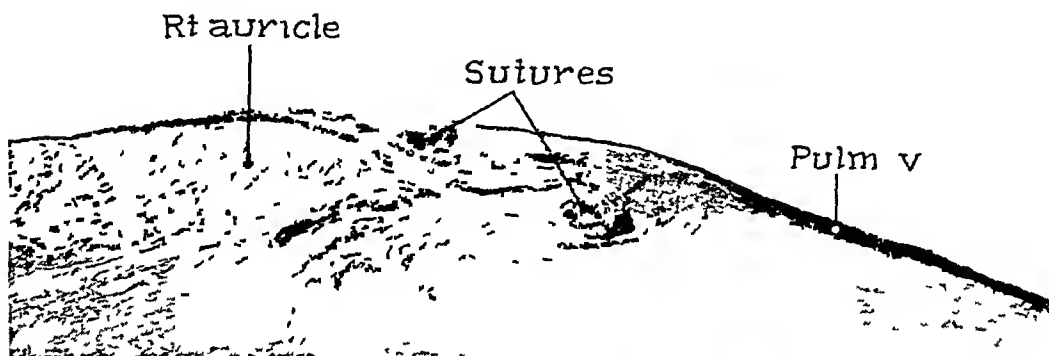


FIG 6—Junction of pulmonary veins and right auricle showing disparity in thickness of walls (30 \times) (Illustration retouched)

Healing is smooth with negligible scarring. The photomicrograph shows the junction of the pulmonary vein and the superior vena cava and illustrates well the similarity in thickness of the vessel walls (Fig 8). Such similarity is in striking contrast to the disparity in thickness of the wall of the pulmonary vein and the right auricle (Fig 6). As previously noted, suture of this thick auricular muscle is frequently accompanied by scarring and obliteration of the anastomosis.

DISCUSSION

The basic difficulty in complete transposition of the aorta and the pulmonary artery is the failure of oxygenated blood to reach the ventricle which empties into the aorta. Survival of such patients is directly related to the degree of interchange between the two sides of the heart by way of persistent fetal passages. Patients with a complete transposition and a patent foramen ovale have lived as long as ten years, and those with a large inter-ventricular defect as a compensatory shunt have lived up to 21 years. A combination of these two compensatory abnormalities allowed one patient

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with a complete transposition to live an essentially normal life for 56 years. However, the average duration of life in a total of 123 reported cases of complete transposition is only 19 months.

The return of pulmonary vein blood into the vena cava or the right auricle provides another possible means of compensation in complete transposition. This condition is occasionally detected as an isolated abnormality at operation or autopsy in patients who have shown no clinical evidence of cardiovascular difficulty. It has also been described as a beneficial adjustment in transposi-

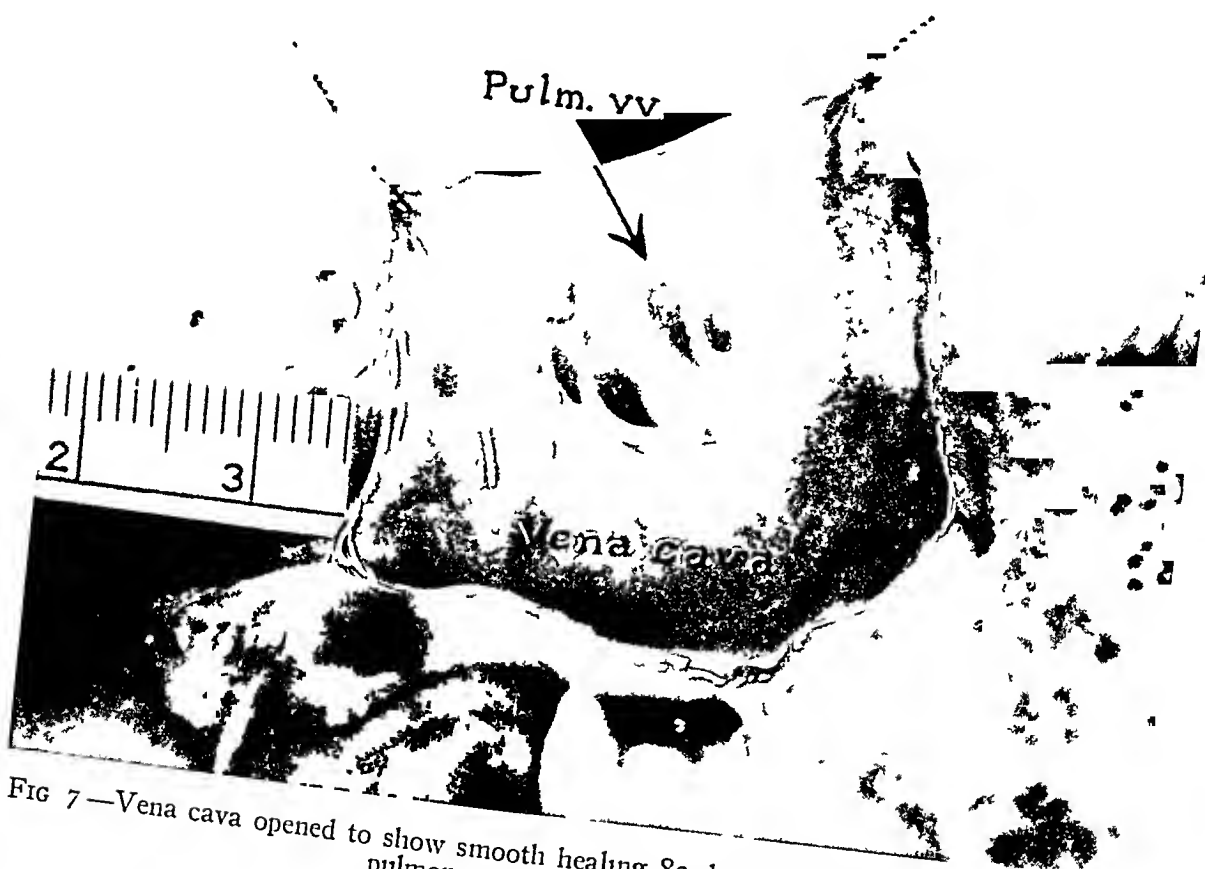


FIG 7—Vena cava opened to show smooth healing 83 days after anastomosis of superior pulmonary veins to vena cava

tion. The possibility of its use in the surgical treatment of transposition prompted the studies detailed here.

These studies consisted of anastomoses in dogs of the veins from the two upper lobes of the right lung to the superior vena cava or the right auricle. In general, the results of anastomosis to the superior vena cava were excellent, whereas anastomoses to the auricle tended to become occluded. It seems likely that the thick auricular wall is poorly adapted to vascular anastomosis. The ability of such anastomoses to return blood to the right side of the heart has been established by catheterization of the superior vena cava and the cardiac chambers. In order to test the therapeutic effectiveness of these anastomoses, however, one must observe their effect on an experimental

animal with complete transposition of the arterial trunks. Since a complete transposition as such would be promptly fatal, it is necessary to establish the corrective pulmonary venous shunt before producing the transposition. Despite a number of efforts which are being continued, we have not yet succeeded in preparing an animal in which a complete transposition of the arterial trunks is corrected sufficiently by artificial shunts to permit life for more than a few minutes.

Despite the failure to reproduce complete transposition in the experimental animal and the consequent inability to test the therapeutic effect of the different shunting procedures, these experiments demonstrate that oxygenated blood may be transmitted to the right side of the heart by way of the transplanted pulmonary veins. The anastomoses to the superior vena cava remained patent up to three and a half months in more than three-fourths of the animals subjected to operation, technical difficulties at operation accounted for partial or complete closure in the remaining animals.

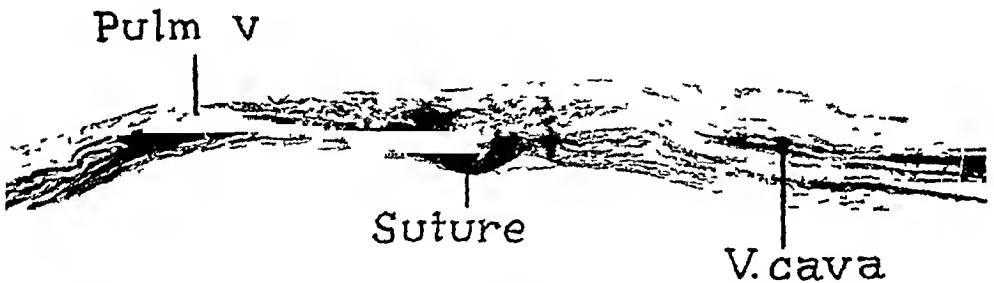


FIG 8—Junction of pulmonary veins and vena cava 30 days after operation (10X)

SUMMARY

In complete transposition of the aorta and the pulmonary artery in man, the time of survival is dependent on the degree of mixing between the greater and the lesser circulations.

Such mixing may be effected by interatrial or interventricular septal defects, by a patent ductus arteriosus, or by entry of pulmonary veins into the transposed right side of the heart. The literature on this point has been briefly reviewed.

The technical feasibility of anastomosing the pulmonary veins to the right auricle or to the superior vena cava has been investigated in the dog.

Anastomosis of the pulmonary veins to the right auricle was usually unsatisfactory whereas an anastomosis of the pulmonary veins to the superior vena cava remained patent in over three-fourths of the experiments.

Anastomosis of the pulmonary veins to the superior vena cava appears

feasible in man and offers one possible approach to the surgical treatment of complete transposition of the great cardiac arteries

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THE SIGMOID AS A SOURCE OF RIGHT-SIDED SYMPTOMS*

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MANY SURGEONS have had the experience of operating upon a patient with symptoms resembling acute appendicitis, only to find a sigmoidal lesion responsible for the clinical signs. Such experience, however, has been reported only as an incidental finding and the frequency of occurrence of left-sided lesions with right-sided symptoms has not generally been recognized. The principal pathological conditions of the colon responsible for the confusion of signs are diverticulitis and carcinoma, especially with perforation.

That the right-sided syndrome is not infrequent is seen from an analysis of the many individual reports of cases and of the summaries dealing with diverticulitis and carcinoma. For example, Allen¹ reported seven cases of carcinoma of the colon to demonstrate the high mortality following perforation. However, his descriptions indicate that of the five sigmoidal cases, three had the chief symptoms and signs on the right side of the abdomen, and in the fourth case the symptoms began on the right, though they later shifted to the left. Examination of a review of diverticulitis by Arnheim² discloses that of the 13 cases with peritonitis, three were operated upon with the diagnosis of acute appendicitis and a fourth case, though known to have diverticulitis, had right-sided symptoms and signs. Young and Young³ summarized statistically 84 cases of diverticulitis of the colon. Their report contains three chronic cases and nine acute cases with symptoms or signs on the right. Some of the patients of Cave and Alsop⁴ who had perforations of inflamed diverticula of the sigmoid were operated upon with a diagnosis of acute appendicitis, and a right McBurney incision was used in some instances. In the series reported by Morton,⁵ pain was present in the right lower quadrant in five instances and tenderness was found occasionally on the right in cases with perforation. Rankin and Grimes⁶ have stated that it is common for acute perforative diverticulitis to present atypical symptoms of acute appendicitis and that the surgeon will often use a right McBurney or right rectus incision. Jones⁷ described a particularly striking case with acute symptoms resembling appendicitis and a palpable mass on the right side of the abdomen which was drained as an appendiceal abscess but was later found to have been the result of a perforated sigmoidal diverticulum. Yet other monographs on diverticulitis,^{8, 9, 10, 11} and on surgery of the colon,^{12, 13} as well as the standard textbooks^{14, 15, 16} and numerous papers^{17, 18, 19, 20, 21} on diverticulitis and carcinoma of the colon, fail to mention the relative frequency of this crossed symptomatology. Even Rankin, Bargen, and Buie,²² while stating that they have observed four cases of diverticulitis in which pain was referred to the right side, further observe that "this is extremely unusual."

The reasons for the referral of pain to the opposite side of the abdomen become clear when one realizes that the sigmoid and rectosigmoid are not always left sided in anatomical position. Roentgenograms of the colon frequently show a rectosigmoid and lower sigmoid to the right of the midline. Lynch²³ suggested that mobility of the lower sigmoid could account for right-sided symptoms resembling appendicitis in cases with diverticulitis. Similarly, Graham²⁴ stated, "Because of the mobility of the sigmoid, it may be in either right or left iliac fossa." Morison⁵ recently mentioned the fact that at operation the sigmoid may be found lying toward the right. Laufman²⁵ and Jones⁷ noted that the sigmoid is very frequently in the midline or on the right side. Moreover, extensive cadaver dissections by Ssosan-Jaroschewitsch²⁶ showed that approximately 11 per cent of sigmoids have a course which is chiefly on the right side of the abdomen.

An additional factor, either in association with other causes or acting independently, may be distention of the cecum. Either organic stenosis or colonic spasm alone can produce intestinal obstruction. Colp²⁷ reviewed all the previous reports and described five additional instances of colonic obstruction produced by spasm. Moreover, in the presence of diverticulitis and sometimes of carcinoma, spasm of the sigmoid without actual obstruction is frequently so marked that the back pressure created in the colon may be focussed chiefly in the cecum. Kantor²⁸ called attention in this country to the occurrence of ulcerations in the cecum due to marked colonic distention, and he further indicated²⁹ that pain in the cecal region could be produced by lesions causing spasm in the distal part of the colon. Although the symptomatology of the cases herein presented was not produced exclusively by cecal distention, this mechanism may have been a contributing factor in some instances.

In the present study 18 cases are reported with lesions in the sigmoid and rectosigmoid which caused right-sided symptoms and signs. In 14 the reference of pain and tenderness to the right was marked enough to prompt operative intervention through incisions placed on the right side of the abdomen.

These cases are used to illustrate the probable causes of the right-sided symptoms: 1 Sigmoid lying over on the right of the midline, 2 Perforation of the right wall of the rectosigmoid with spillage of fluid toward the right, 3 Perisigmoidal abscess extending to the right, 4 Adherence of right-sided structures to the sigmoidal lesion, 5 Situs inversus.

SIGMOID LYING ON THE RIGHT

Case 1 (Admission No 480580) J. F., a 58-year-old man, was admitted to The Mount Sinai Hospital on October 18, 1941, with a history of lower abdominal pain for one day, shifting shortly after onset to the right lower quadrant.

On physical examination, temperature was 101°. There was tenderness in both lower quadrants of the abdomen, most marked on the right, with rebound tenderness on the right.

The preoperative diagnosis was acute appendicitis.

Operation was performed on October 18, 1941, through a right McBurney incision. A loop of redundant sigmoid lay on the right side of the abdomen. The wall was markedly reddened and swollen over an area about one-half inch in diameter at the attachment of

the mesentery, which was also edematous. Flakes of fibrin covered this localized, reddened area. A small amount of free, cloudy, peritoneal fluid was present. The appendix was normal. The sigmoid area was drained.

The final diagnosis was acute diverticulitis.

Case 2 (Admission No 526864) M K, a 52-year-old man, was admitted to The Mount Sinai Hospital on November 1, 1944. In the past he had had intermittent attacks of right lower quadrant pain. Two days before admission he had severe lower abdominal pain, associated with nausea and fever.

Physical examination showed a temperature of 100. There was marked tenderness and spasm in the right lower quadrant, especially over McBurney's point.

The preoperative diagnosis was acute appendicitis.

Operation on November 1, 1944 was performed through a right McBurney incision. The appendix, which pointed medially, seemed mildly inflamed by contiguity with a markedly inflamed sigmoid which lay near the appendix. The appendix was removed. Pathological report showed it to be normal.

The final diagnosis was acute diverticulitis.

Case 3 (Admission No 446923) G H, a 56-year-old man, had chronic constipation for many years. Six days before admission the constipation became more marked. Six hours before admission he had severe lower abdominal pain, most marked on the right. He was admitted to The Mount Sinai Hospital on October 7, 1939.

On physical examination, the temperature was 99.6. There was diffuse abdominal tenderness, most marked in the right lower quadrant where there was marked spasticity.

The preoperative diagnosis was acute appendicitis.

Operation on October 7, 1939 was performed through a right lower Kammerer incision. The sigmoid was found drawn over to the right. The incision was closed and a left-sided incision made. Free feces was then found extruded from a "laceration" of the sigmoid. There was diffuse peritonitis. The perforation was closed by suture and the sigmoid area drained.

The final diagnosis was perforated diverticulitis with peritonitis.

Case 4 (Admission No 503664) F O, a 57-year-old man, was admitted to The Mount Sinai Hospital on May 31, 1928 with a 48-hour history of severe abdominal pain localizing in the right lower quadrant. He had had a preceding attack of pain which was thought at the time to be due to appendicitis.

On physical examination there was marked tenderness in the right lower quadrant. "Typical signs of peritonitis involving the lower half of the abdomen" were present.

The preoperative diagnosis was acute appendicitis.

Operation on June 1, 1928, was performed through a right rectus muscle splitting incision. There was a small amount of free peritoneal fluid. The sigmoid was over on the right side. It was thickened and "inflamed." The epiplocae were many times normal in size. The area about the sigmoid was drained. A normal appendix was removed.

The final diagnosis was acute diverticulitis.

COMMENT ON CASES 1, 2, 3, 4

In the four cases described above, the acutely inflamed sigmoid was found on the right side of the abdomen and was clearly responsible for symptoms and signs resembling acute appendicitis, by producing irritation of the parietal peritoneum in the right iliac fossa.

Case 5 (Admission No 440483) A N, a 71-year-old woman, was admitted to The Mount Sinai Hospital on May 16, 1939 with a one-day history of gradually increasing generalized abdominal cramps, associated with nausea. Her maximum pain was in the suprapubic region. She had a chill and temperature rise to 104.

SIGMOID AND RIGHT-SIDED SYMPTOMS

On physical examination, temperature was 101. The abdomen was markedly distended. There was generalized tenderness, rebound, and spasm, all of which were most marked suprapubically and in the right lower quadrant. On rectovaginal examination, most tenderness was on the right.

The preoperative diagnosis was appendicitis with peritonitis.

Operation on May 16, 1939 was performed through a right lower rectus muscle-splitting incision. Thick, non-odorous pus was found coming from the pelvis. The appendix was seen to be normal. The sigmoid was easily delivered and found to be acutely inflamed and swollen. The epiplocae were thick and reddened. No perforation was seen. Appendectomy was performed. The sigmoid region was drained. The pathological report was acute peri-appendicitis. The culture of pus showed *B. coli*.

The final diagnosis was acute perforative sigmoiditis.

COMMENT ON CASE 5

The signs in the midline and on the right side resembled those of pelvic appendicitis. The causative mechanism of the right-sided signs is not definitely known here, but from the operative description the easy delivery of the sigmoid through a right-sided incision suggests a position of the sigmoid to the right of the midline. The participation of the cecum in the general distention may have contributed to the right-sided signs.

PERFORATION WITH SPILLAGE OF FLUID TOWARD THE RIGHT

Case 6 (Admission No. 502490) M. F., a 57-year-old man, was admitted on March 6, 1943. For two weeks the patient had had mild lower abdominal cramps, more severe in the 24 hours before admission. Low grade fever was present for one day. Because no urine had been passed for 24 hours, catheterization was performed, with the evacuation of 100 cc. of bloody urine.

On physical examination the temperature was 101.6. The patient appeared very ill. There was distention and spasticity in the lower abdomen, slight bilateral tenderness, and distinct right costovertebral tenderness.

He was first admitted to the Urological Service. Cystoscopy and intravenous pyelogram on admission however were essentially normal. The abdominal signs became more localized on the right side where definite rigidity developed.

The diagnosis was altered to peritonitis due to ruptured appendix or cecal neoplasm.

Operation on March 7, 1946 was performed through a right lower rectus muscle-splitting incision. A great deal of cloudy fluid escaped from the peritoneal cavity. The cecum and appendix were normal. The gallbladder and stomach were normal on palpation. The small intestinal loops were packed away in order to visualize the sigmoid. A firm mass was seen and felt in the sigmoid on the right wall of which was a free perforation about 2 millimeters in diameter. The sigmoid was then exteriorized through a small left-sided incision and later excised.

The pathologic diagnosis was adenocarcinoma of the sigmoid with perforation.

Case 7 (Admission No. 375348) R. S., a 28-year-old man, was admitted on January 5, 1935. Seven months before admission the patient had sharp right lower quadrant pain lasting a few hours. Six weeks before admission he had dull pain in the right lower quadrant associated with vomiting and diarrhea. There was one shaking chill. Pain subsided after three days.

Fourteen hours before admission the patient was seized with periumbilical pain radiating to the right lower quadrant and to both testes, associated with nausea. He vomited once. He had one marked shaking chill. One soft stool was passed shortly after the onset of pain.

On physical examination the temperature was 103.4. There was tenderness, rigidity, and rebound tenderness in both the right and left lower quadrants. On rectal examination there was a bulge felt anteriorly above the prostate. There was marked tenderness on the right and less tenderness on the left.

The preoperative diagnosis was acute appendicitis with perforation.

Operation on January 5, 1935 was performed through a right lower rectus muscle-splitting incision. On opening the peritoneal cavity a thin, greenish-yellow fluid exuded (Smear showed gram positive cocci.) The appendix was normal. Pus was then seen oozing from the pelvis. The loops of small intestine were packed away to expose the sigmoid. Close to the mesenteric border was a necrotic looking area, about 1.5 cms in diameter, with a tiny hole in its center. The perforated area was sutured and drained.

The final diagnosis was inflammatory perforation of the sigmoid, probably due to diverticulitis.

Case 8 (Admission No. 394043) H. L., a 5-year-old boy, was admitted on June 3, 1936. He had a rectal polypectomy performed by suture and excision. A few bloody stools followed. Five days later he was seized with severe abdominal pain and a strong urge to defecate. He vomited once.

On physical examination, five hours after onset of symptoms, the patient had generalized abdominal tenderness and rigidity, definitely most marked in the right lower quadrant. Liver dullness was obliterated (Roentgen examination of the abdomen showed air under both leaves of the diaphragm.) On rectal examination a small nodule could be felt 1½ inches above the anus at the site of the polyp excision.

The preoperative diagnosis was ruptured viscus (possibly related to the rectal operation) or acute appendicitis with perforation.

Operation on June 3, 1936 was performed through a right paraumbilical muscle-splitting incision. When the peritoneum was opened, gas and odorless purulent fluid escaped. The cecum was delivered to expose a long, apparently acutely inflamed appendix, which was removed. Purulent fluid, however, kept coming from the rest of the peritoneal cavity. The stomach and gallbladder were palpated but no lesion was discovered. The sigmoid was then exposed. A firm, indurated mass was found about 6 centimeters above the level of the peritoneal reflection. Exudate overlay a perforation about one-half centimeter in diameter. The hole was closed and the area drained. The pathological report was periappendicitis.

The operator stated that he thought the perforation was too high in the sigmoid to be due to the polyp excision in the rectum.

COMMENT ON CASES 6, 7, AND 8

In these three cases the right-sided signs were apparently chiefly due to perforation on the right wall of the sigmoid with spillage of fluid toward the right. The absence of surrounding omentum may have more easily allowed this tracking of fluid.

In Case No. 8, the slightly reddened appendix was merely part of the contiguous inflammation as is seen by the pathological report. Further exploration before removal of the appendix would have been better, for the degree of inflammation in the appendiceal wall was clearly not sufficient to account for the clinical findings or the free pus in the peritoneal cavity.

Case 9. (Admission No. 420291) P. F., a 32-year-old woman, was admitted on February 15, 1938, because of sudden, severe, generalized abdominal pain beginning several hours before admission, followed by nausea and vomiting. The temperature rose abruptly to 103.8.

On physical examination the abdomen was distended. There was general abdominal tenderness, most marked in the right lower quadrant, where spasm was also present.

Operation was performed shortly after admission. A low midline incision was used. A large amount of free pus escaped from the peritoneal cavity. The sigmoid was found to be the site of a surrounding purulent infection. The appendix was removed. The pelvis was drained.

The lesion was finally discovered at autopsy to be due to an adenocarcinoma of the sigmoid with perforation into the cul de sac.

COMMENT ON CASE 9

Although most of the abdominal signs were clearly on the right, the sudden onset and rapid progression of generalized abdominal symptoms apparently suggested the possibility of a perforated left-sided lesion, for a midline incision was used. Cecal distention of course may well have contributed to the tenderness in the right lower quadrant.

Case 10 (Admission No. 465843) M. F., a 68-year-old woman, was admitted on November 27, 1940. She had had a sense of fullness in the lower abdomen for one day. A few hours later she was awakened from sleep by sharp, generalized abdominal pain. Her family physician found marked tenderness and spasticity limited to the entire right side of the abdomen. The pain persisted for several hours, was associated with nausea and vomiting, and finally seemed to localize in the right lower quadrant.

On physical examination the temperature was 101. Tenderness was found to be most marked in the left lower quadrant, although shortly before admission the signs were all right-sided. Most of the tenderness on pelvic examination was on the right.

Operation on November 28, 1940 was performed through a right lower rectus muscle-splitting incision. No free fluid was found. The appendix was normal. A mass was found in the left lower abdomen involving the lower sigmoid and "adherent to all the surrounding structures." The mass had perforated into the general abdominal cavity. The sigmoidal area was drained.

Autopsy showed multiple diverticula with perforations, and a pericolic abscess perforating into the posterior cul de sac. There was also a hemorrhagic pulmonary infarct.

COMMENT ON CASE NO. 10

Unmistakable right-sided symptoms and signs were present before admission to the hospital. After admission, the abdominal signs were chiefly left-sided and the pelvic findings right-sided. Though perforated diverticulitis was considered, the most likely diagnosis was appendicitis, for a right-sided incision was used. This case is classified as probably due to spillage of fluid toward the right, but adherence of small bowel to the sigmoid area may have been a cause of the referral of pain to the right.

Case 11 (Admission No. 512894) A. A., a 42-year-old man, was admitted on July 27, 1943. Sixteen hours before admission the patient developed lower abdominal crampy pain. He took a teaspoonful of Epsom salts. One hour later he began to have small bowel movements. Pain increased in severity and he vomited. Pain was predominantly in the midline, but also in both lower quadrants. He had a shaking chill.

On physical examination the temperature was 100.6. The abdomen was markedly distended. There was marked tenderness and spasm of the entire lower abdomen. On rectal examination, tenderness was limited to the right side.

The preoperative diagnosis was perforated appendicitis

Operation on July 27, 1943 was performed through a right Kammerer incision. Thin cloudy fluid escaped from the peritoneal cavity. The cecum and appendix were normal. A mass was palpated and seen in the mid-sigmoid containing a perforation oozing fecal fluid. There was very little peritoneal reaction. The sigmoid was exteriorized through a left-sided incision and the involved area ablated. The pathologic report revealed a perforated diverticulitis.

COMMENT ON CASE NO 11

The abdominal symptoms and signs were in the midline and in both lower quadrants, though rectal tenderness was on the right. The paucity of local reaction to the perforation, allowing the tracking of fluid throughout the peritoneal cavity, may have accounted for equal distribution of abdominal signs between right and left sides. Although the right-sided signs were not predominant (except for rectal findings) this case is included because to all observers the clinical picture simulated perforated appendicitis.

PERISIGMOIDAL ABSCESS WITH EXTENSION TO THE RIGHT

Case 12 (Admission No 509520) Y K, a 42-year-old woman, had had anorexia, cramps and diarrhea for three months, with pain in both lower quadrants. Five weeks before admission she was operated upon at another hospital through a right rectus incision and an abscess in the right iliac fossa was drained. The appendix, normal on pathological examination, was removed. Two weeks later the patient was admitted to The Mount Sinai Hospital after having a sudden chill, followed a few hours later by pain in the right lower quadrant.

On physical examination the temperature was 103.6. There was distinct tenderness in the right lower quadrant. A large, ill defined mass was palpable in the region of the right rectus incision scar. On pelvic and rectal examinations, tenderness was present on both sides.

Under observation the symptoms and signs progressed. The preoperative impression was that the right lower quadrant abscess had probably originally been due to a terminal ileitis with perforation.

Operation was performed through an incision lateral and parallel to the previous right rectus scar. A large omental mass extending towards the left side was found in the right iliac fossa. This area was drained though no pus was encountered. On the fifth postoperative day there was spontaneous discharge of copious foul-smelling pus from the drainage tract. The lesion was water found at another operation to be a rectosigmoidal carcinoma with perisigmoidal abscess.

Case 13 (Admission No 418912) E G, a 55-year-old woman, was admitted on January 11, 1938. For one year she had occasional blood streaked stools and a gradual loss in weight. Two weeks before admission the patient had a shaking chill followed by pain in the right lower quadrant which became constant.

On physical examination the abdomen was soft but distended. There was deep tenderness above Poupart's ligament on the right with some muscular spasm. A fulness could be felt in the right lower quadrant though no distinct mass was palpable. Rectal and pelvic examinations disclosed a tender mass to the right of the cervix.

The admission diagnosis was appendiceal abscess. The possibility of a perisigmoidal abscess due to a perforating carcinoma was considered, but the symptoms and signs were so clearly on the right that a right-sided incision was made for exploration.

Operation on January 14, 1938 was performed through a low right rectus muscle-splitting incision. There was thin, free peritoneal fluid. An abscess was found in the

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pelvis behind the uterus, extending up toward the cecum After suitable walling off with pads, the abscess was drained

At autopsy the rectosigmoid contained a carcinoma which had perforated into an abscess cavity lying behind the right tube and ovary

Case 14 (Admission No 418348) R S, a 48-year-old woman, was admitted on December 29, 1937 with a five-week history of persistent lower abdominal cramps, marked constipation except for one episode of diarrhea, anorexia, loss of weight and fever Barium enema at another hospital two weeks before admission was said to show no abnormalities

On physical examination the temperature was 104 The abdomen was distended and slightly tender, chiefly in the right lower quadrant, where a sausage-shaped mass was palpable On pelvic examination a firm, spherical, fixed mass was felt in the cul de sac The pelvic mass seemed to be continuous with the abdominal mass

The possible diagnoses considered included perforation of the small bowel, carcinoma of the sigmoid, and finally uterine fibroids with degeneration

Operation on January 1, 1938 was performed through a left lower rectus incision A huge mass was found filling the pelvis and extending up as far as the umbilicus Across the front of the mass coursed the sigmoid The mass was entered on the right side with evacuation of pus It was then seen that the perforation of a sigmoidal tumor was the cause of the abscess

The final diagnosis was carcinoma of the sigmoid with perisigmoidal abscess

COMMENT ON CASES NOS. 12, 13, AND 14

Right-sided symptoms and signs in these three cases were caused by extension to the right of an abscess arising in the pelvis around the sigmoid and rectosigmoid

In Case No 12 the bulk of the abscess presented itself in the right iliac fossa In Case No 13, the diagnosis of perisigmoidal abscess due to carcinoma was considered but the virtual limitation of symptoms and signs to the right side of the abdomen prompted operation through a right rectus incision In Case No 14, although the abdominal signs were mainly on the right and the mass was felt to the right of the umbilicus, a left-sided incision was used because a degenerated uterine fibroid was thought to be the cause However, at operation the sigmoid was found extending toward the right and the most accessible part of the abscess was also to the right of the midline

Case 15 (Admission No 513892) I K, a 41-year-old woman, was admitted on December 4, 1943 One month before admission the patient was seized with sudden, severe, right lower quadrant pain requiring a hypodermic injection The pain subsided but then recurred intermittently It was always located in the right lower abdomen The day before admission the pain increased in severity and was associated with nausea and vomiting

On physical examination the temperature was 101.8 There was direct and rebound tenderness in the right lower abdomen A midline mass was palpable above the pubis On pelvic examination a firm, very tender mass, the size of a grapefruit, was felt overlying the uterus and filling the right adnexal region

The preoperative diagnosis was right ovarian neoplasm with torsion

Operation on December 4, 1943 was performed through a midline incision On separating the omentum, which was adherent to the pelvic structures, an abscess cavity was entered to the right of the uterus, yielding fecal smelling pus The sigmoid loop lay across the midline and was adherent to the uterus The actual point of perforation was

not seen, but one wall of the abscess cavity was composed of an indurated area in the sigmoid. The sigmoid was exteriorized and its limbs were approximated to form a spur. The final diagnosis was perisigmoidal abscess.

COMMENT ON CASE NO 15

The symptoms and signs were apparently due both to the course of the sigmoid across the midline and to the location of the abscess to the right of the uterus.

Case 16 (Admission No 513839) M B, a 65-year-old woman, was admitted on December 2, 1943. After being previously well, the patient had sudden right lower quadrant pain associated with nausea and vomiting one day before admission. The symptoms gradually increased in severity.

On physical examination the abdomen was distended. Marked tenderness and spasm were present in the right lower quadrant. There was also slight tenderness in the left lower quadrant.

The preoperative diagnosis was acute appendicitis with possible perforation.

Operation on December 2, 1943 was performed through a right lower rectus muscle-splitting incision. There was a small amount of free peritoneal fluid. The appendix was normal. The sigmoid was exposed. An area of induration was found in the sigmoid with a surrounding abscess which was drained.

The final diagnosis was perisigmoidal abscess due to perforated diverticulitis.

COMMENT ON CASE NO 16

Typical symptoms and signs of acute appendicitis were caused by a perisigmoidal abscess, but the mechanism of the crossed symptomatology in this case is not clear from the operative description. Here, too, cecal distention may well have been partially responsible for the symptoms and signs on the right.

ADHERENCE OF RIGHT SIDED STRUCTURES TO THE SIGMOID

Case 17 (Admission No 415178) F C, a 39-year-old man, was admitted on October 9, 1937. For eight days before admission the patient had lower abdominal cramping pain. There was mild nausea and one episode of vomiting. His physician diagnosed "subsiding appendicitis." On the night before admission, following an enema, the lower abdominal cramps became more severe and finally shifted to the right lower quadrant.

On physical examination the temperature was 102.8. Tenderness and rigidity were found in both lower quadrants, most marked on the right. There was a firm, tender mass filling most of the right lower abdomen and extending into the left lower quadrant. On rectal examination, tenderness was felt on the right.

The preoperative diagnosis was appendiceal abscess.

Operation on November 6, 1937 was performed through a right lower rectus muscle-splitting incision. The appendix was found lying free, "moderately injected," with an apparently blunted tip. Appendectomy was performed. Further exploration, however, revealed an abscess in the left iliac fossa, surrounded by omentum and loops of small intestine. The cavity was entered and drained. Later roentgen studies of the sigmoid showed diverticulitis.

COMMENT ON CASE NO. 17

Although the sigmoid and the perisigmoidal abscess were located in the left iliac fossa, the symptoms and presenting mass on clinical examination were

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on the right. The symptoms may have been due to the adherence of the small bowel loops to the perisigmoidal abscess. The mass palpated on the right side was apparently matted small intestinal loops forming and covering the abscess wall. It is of interest to note that right-sided symptoms again were the presenting complaints one and a half years after recovery from the first attack.

The following case was previously described by Ainhem² in his study of diverticulitis, but is here presented as another instance of right-sided symptoms produced by adherence of right-sided structures to a sigmoid lesion.

Case 17A (Admission No 345651) P K, a 57-year-old man, was admitted on November 14, 1932 with the history of right lower quadrant pain and constipation for four months, loss of weight for two months, and a chill two weeks before admission.

On physical examination the temperature was 98.6 degrees. Tenderness was present in the right upper abdomen. Barium enema studies, however, revealed many diverticula of the sigmoid with spasm.

Operation was performed through a left-sided incision. The sigmoid was short and fixed, and contained several diverticula. An abscess posterior to the sigmoid was entered and 2 ounces of thick, creamy, odorless pus was evacuated.

At autopsy there was an inflammatory mass involving the sigmoid, omentum, and a loop of ileum. At the site of attachment of the ileum to the sigmoid there was an ileosigmoidal fistula.

SITUS INVERSUS

Case 18 (Admission No 527537) F K, a 63-year-old woman, was admitted on November 18, 1944. In the three years before admission the patient had attacks of right lower quadrant pain associated with the urge to defecate, relieved by passage of gas. She had lost 15 pounds in the past year. Four days before admission a particularly severe attack of right lower quadrant pain occurred, associated with left flank pain and nausea. A mild chill occurred.

On physical examination the temperature was 100.4. The abdomen was soft. In the right lower abdomen extending out to the right flank was an ill defined, soft, tender mass which did not move on respiration. There was no tenderness on pelvic and rectal examinations.

The preoperative diagnosis was appendiceal abscess. The possibility of a cecal neoplasm or cecal diverticulitis was considered.

Operation on November 20, 1944 was performed through a right lower rectus incision. On opening the peritoneum, the sigmoid presented itself in the wound. A mass was present in the right wall of the sigmoid which seemed to be bound to the right lateral peritoneum. The area around the mass was drained and the wound closed, leaving the subcutaneous tissues packed open.

Barium enema disclosed a situs inversus of the intestinal tract, and showed diverticula with spasm in the sigmoid colon.

COMMENT ON CASE NO 18

The sigmoid is a right-sided organ in situs inversus and therefore would be expected to produce symptoms on the same side. This case is included merely for completeness to illustrate one of the possible mechanisms of the production of right-sided symptoms by a sigmoid lesion.

SUMMARY AND CONCLUSIONS

1 Right-sided abdominal symptoms and signs are often produced by sigmoidal lesions. Acute appendicitis is the commonest preoperative diagnosis in these instances.

2 The principal causes for the right-sided symptomatology in acute diverticulitis and carcinoma of the sigmoid are

- a Sigmoid lies on the right side of the abdomen as a result of its mobility or the anatomical variations in its course,
- b Perforation of the right wall of the sigmoid with spillage of exudate into the right iliac fossa,
- c Extension of a perisigmoidal abscess to the right,
- d Adherence of right-sided structures to the sigmoidal lesion,
- e Marked distention of the cecum,
- f Situs inversus

Eighteen cases are reported in illustration (5 with carcinoma and 13 with diverticulitis).

3 Inspection of the sigmoid should be included in the exploration of the abdomen before removal of the appendix, when at operation insufficient cause for the clinical findings is discovered in the right iliac fossa.

The cases in this paper are from the Surgical Services of Drs John H Garlock, Ralph Colp, and Harold Neuhof, and include three private cases from the services of Drs Albert A Berg, Leon Ginzburg, and Myron Sallick.

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NEW DONOR AREAS IN SKIN GRAFTING

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WITH THE INTRODUCTION of the dermatome in 1939,¹ the taking of calibrated skin grafts became fairly simple. However, it soon became apparent that this was limited in its scope by the irregularities in the surface of the prospective donor areas. Adequate grafts could be taken from the thighs, abdomen and back in a thin individual, and in addition from the chest in an obese individual. Many cases, however, are seen in which the above donor areas have been destroyed by burn. The only areas of normal skin remaining are on the chest, upper back, and scapula where by the time the individual is ready for grafting, the surface is too irregular to take a graft because of the



FIG 1—Chest showing prominent ribs

wasting of the subcutaneous tissue and the protuberance of the underlying bone. The taking of Thiersch grafts with the Ferris-Smith knife is usually limited to the thighs or the upper arms.

Grafts can be taken from practically all irregular areas by injecting saline beneath the skin, with obliteration of the depressions. A search of the literature failed to reveal any article in which this had been described. This method may possibly have been used elsewhere unknown to the present author, however it has apparently not been published in medical literature so that the other surgeons might utilize it.

TECHNIC

An area of normal skin slightly larger than the dermatome is marked out with methylene blue. Using a 30 cc syringe and a long needle, normal saline

FIG 2



FIG 3

FIG 2—Smooth contour after subcutaneous saline

FIG 3—Graft taken from area

solution is injected beneath the skin in the area outlined by the methylene blue. Care should be taken that the needle is not put through the skin at any point in the rectangular area outlined by the ink. In the first case in which this was used the needle entered the normal skin area where the graft was to be taken, and the saline leaked out onto the donor skin before the skin cement was applied. After all of the irregular areas have been obliterated the area is cleansed well with ether and the Padgett cement is applied. After the cement has dried thoroughly for five minutes the graft is taken in the usual manner.

The first case upon which this was used was an emaciated male, age 22, burned in an airplane crash. The only normal skin available was over the sternum and the scapula. Grafts were taken from both of these areas in this patient. In another patient, although some other donor areas were available it was felt that the work could be completed faster by using sheets of skin larger than those available with the Padgett dermatome. The dermatome used here was a special one taking a graft 6 by 10 inches, or nearly twice the area of skin taken with the Padgett machine. The use of this type of dermatome is usually limited to circular grafts of the thigh, or the occasional graft from the chest in an obese individual. Figure 1 shows a preoperative view of the donor area, showing marked irregularity of the chest. This patient had an estimated 40 per cent burn on admission. Figure 2 is a close-up of the area demonstrating the marked smoothness of the donor skin that can be obtained with subcutaneous saline. Figure 3 shows a graft of 60 square inches taken from the chest. This method can also be used for taking free hand grafts. An irregular chest, scapular, or back area can be used after subcutaneous injection of saline.

SUMMARY

A method is presented whereby irregular skin areas may be utilized as donor areas using the dermatome, or by cutting the graft free hand. This is accomplished by injection of normal saline beneath the prospective donor area.

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GASTRODUODENAL ULCER, A SPASTIC DISEASE

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ALTHOUGH hundreds of gastrectomies are performed daily there is still no unanimity of opinion as to the underlying cause of ulcers of the stomach and duodenum. Clinical, pathologic and experimental investigations have failed to solve the problem completely. The German occupation of Holland, 1940-1945, during which the entire population of nine million people were medically, *de facto* experimental subjects,* furnished a great deal of material which may throw some light on the theory of ulcer formation.

Both psychical and alimentary disturbances during the occupation may have affected the gastrointestinal tract. In Holland, as in the United States, an increased number of ulcers occurred immediately after the outbreak of war. This early rise may be attributed to psychic factors such as fear, sorrow, and rage, since at that time there was no appreciable change in food supplies. Shortly thereafter important changes in diet of the Dutch people occurred, and this was accompanied by a great increase in incidence of gastroduodenal ulcers. For many years the daily intake consisted of a total of about 1600 calories, with a relative diminution in consumption of protein and of fat, and an increase in carbohydrates. Potatoes, a food high in cellulose, were eaten in much larger quantities than normal. These changes produced an increased peristalsis throughout the gastrointestinal tract of nearly the whole population. Many persons even suffered from non-bacterial diarrhea throughout the entire period of the occupation.

The incidence of other diseases was also changed during the occupation. Some increase in the number of operations for gallstones was noted. Lack of fat probably kept this increase small, for immediately following the liberation, when the fat supply improved, we saw innumerable gall-bladder cases. Volvulus, especially of the sigmoid, strangulated herniae and anal fissures were observed in greater numbers, while there was a diminution in the incidence of acute appendicitis (Table I). *† Volvulus and anal fissure are conditions known to be associated with either increased peristalsis or spasticity of part of the intestinal tract. Spasticity of the sphincter of the anus can be directly observed in cases of anal fissure. Increased peristalsis, preventing stagnation of secretions in the appendix, may also explain the decrease in appendicitis.

* The observations of this huge experiment were collected and studied by a team of 21 investigators, most of them connected with Dutch Universities, and described in "Medical Experiences during the Occupation of The Netherlands 1940-1945."

† Figures in this paper do not include the years 1944 and the first half of 1945. During this time the city populations were so changed because of inundations, displacements and bombardments that a quantitative comparison with normal times is impossible.

These observations lead to the conclusion that there was an increase in peristalsis and a tendency to spasm in the intestinal tract of many Dutch people during the occupation. It seemed probable that similar conditions might also exist in the stomach and duodenum. Table II gives the statistics on ulcer cases operated upon during this period. It is our theory that the increase in the number of ulcers may be a direct result of the spastic condition assumed to exist also in the upper intestinal tract.

TABLE I—*Incidence of Volvulus, Anal Fissure and Appendicitis*

	1938	1939	1940	1941	1942	1943	1944
Operated cases of volvulus, large and small intestine (All clinics in Groningen)	1	4	5	6	15	11	
Cases of anal fissure (Surgical clinic Groningen)							
Men	2	5	3	9	6	8	13
Women	2	5	0	8	6	11	9
Total	4	10	3	17	12	19	22
Cases operated appendicitis (all hospitals in Groningen)							
Men	481	468	345	346	343	318	
Women	464	494	375	398	400	379	
Total	945	962	720	744	743	697	

TABLE II—*Increase in Frequency of Gastroduodenal Ulcer*

	1938	1939	1940	1941	1942	1943
Operated cases non perforated gastric and duodenal ulcers (All hospitals, Groningen)						
Men	81	96	86	144	158	260
Women	10	21	22	28	21	25
Total	91	117	108	172	179	285
Operated cases gastric ulcers (University Hospital, Groningen)						
Men	2	11	14	36	15	27
Women	2	1	1	4	1	0
Total	4	12	15	40	16	27
Operated cases duodenal ulcers (University Hospital Groningen)						
Men	18	14	15	33	16	35
Women	1	2	0	4	0	0
Total	19	16	15	37	16	35

Pyloric hypertrophy in adults in Holland was frequently observed, an indication of increased frequency of a spastic condition of the stomach. Roentgenologists demonstrated many cases where the entire antrum of the stomach was rigid. laparotomy revealed neither cancer nor ulcer, but hypertrophy of the pylorus. Spasm of the entire antrum probably occurred in such cases. One such patient, a woman of 72, had heavy cramps in the stomach and diarrhea, after meals. Cancer was suspected because of a stiff antrum, but resection of part of the stomach and of the upper part of the duodenum

showed only a very thick pylorus. Such direct observations of increase of frequency in spasm in the stomach sustain the neurogenic theory of ulcer of Von Bergmann. According to this theory, local spasms cause ischemia in the wall of the gastroduodenum, after which digestion takes place of it.

Acidity of the gastric secretion decreased, rather than increased, during the occupation. Hence these observations do not support the theory of high acidity as the cause of gastroduodenal ulcer. Neither can the increase in ulcer cases be attributed to emboli in the gastroduodenal wall. Actually, as indicated in Table III, thrombo-embolism decreased in frequency, and even almost disappeared during the last two years before the liberation, but resumed its prewar incidence within three months thereafter. A fourth theory, that gastroduodenal ulcer is a complication of chronic gastritis, is not borne out by our observations. Although there was a great increase in diarrhea among the Dutch population, this was mostly nonbacterial in origin. Studies of infection in operative wounds and of hematogenous osteomyelitis indicate that the people of Holland were no more susceptible to infection during the first three years of the occupation than before the war.

TABLE III—*Incidence of Postoperative Thrombosis and Embolism*

	1938	1939	1940	1941	1942	1943
Postoperative thrombosis and embolism (Surgical Clinic, Groningen)	30	33	28	12	13	14
Fatal pulmonary embolism	11	17	7	3	2	1
Non fatal pulmonary embolism (Postmortem examinations, Binnen Gasthuis Amsterdam)	61	76	54	20	14	9

TABLE IV—*Incidence of Prolapse of Rectum and Anus*

	1938	1939	1940	1941	1942	1943
Operated prolapsus ani and recti (Surgical Clinic, University Hospital, Groningen)	4	12	16	18	28	24

Our conclusion is, therefore, that gastroduodenal ulcer is a spastic disease whose etiology is best explained by the theory of Von Bergmann.

A study of spastic conditions in children of various ages was made in order to determine whether psychic or nutritional factors were more important in causing intestinal spasm. Breast-fed babies may be assumed to be relatively uninfluenced by war, either psychically or in actual feeding. In this group we observed no changes during the occupation from pre-war levels of frequency of pylorospasm. Children of one year were at an age to be somewhat affected by food changes. This group showed a small but distinct increase in the incidence of ileocecal intussusception, a spastic disease occurring most frequently at this age. Children of four to five years, still uninflu-

enced psychically by the war, suffered as much as adults from the change in food supply. In this age group, as shown in Table IV, a substantial increase in prolapse of the mucous membrane of the rectum and anus occurred. This condition is associated with an increase in peristalsis and spasm of the lower part of the bowel. These observations of children indicate that changes in the physiology and pathology of the bowel are influenced in the first place by the food ingested.

The above considerations cause us to examine the rationale for the hundreds of resections for treatment of gastroduodenal ulcer performed daily. Our experiences during the occupation lead us to conclude that diminishing the gastric acidity can not be the cause of the success of gastric resection. Removal of the ulcer, *per se*, is not the reason, as from our experience it is immaterial whether the duodenal ulcer is removed or left *in situ*, provided at least half the stomach, including the pylorus, is removed. The chief effect of resection seems to us to be the removal of that part of the gastroduodenum most susceptible to the spasm which we assume to be the direct cause of the ulcers.

This study, while not affecting therapy, has, in fact, led us to the conviction that gastroduodenal ulcer is a spastic disease.

RATIONALE OF PARENTERAL GLUCOSE FEEDING IN THE POSTOPERATIVE STATE

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GLUCOSE serves two purposes in the postoperative state if administered properly. It acts to prevent starvation ketosis, and to minimize protein catabolism by exertion of its protein sparing effect.

Ketosis always occurs when the liver lacks adequate glycogen stores. Muscles and other tissues may be provided with all the carbohydrate necessary for their normal metabolism, but ketosis still develops if the liver is deprived of available glycogen supply. Ketosis, if it emerges and is allowed to persist, leads to a progressive deterioration of the architecture of the hepatic cell, since the ketone bodies, *i e*, β -hydroxybutyric and acetoacetic acids, which are formed exclusively in the glycogen deprived liver, alter the hydrogen ion concentration, and, at the same time, the electrolyte pattern of the cells. These changes inevitably interfere with the enzymatic reactions and the immunologic functions of the liver. In a word, normal hepatic function is incompatible with ketosis.

Lack of hepatic glycogen initiates, in addition to ketosis, a second adverse process, in that it compels the body to burn increased amounts of protein as well as fat. It is well known that depletion of the protein reserves of the liver is as harmful to normal liver function as exhaustion of the glycogen stores, both being essential elements in the normal physico-chemical structure of the liver cell.

In the immediate postoperative period one or more of three factors may be conducive to hepatic glycogen deficiency. One factor is the glycogenolytic effect of certain anesthetics which accelerates the conversion of liver glycogen into blood sugar and thereby substantially depletes the glycogen reserve. A second factor is the often necessarily imposed inadequacy of oral food intake directly following operation which, especially when superimposed upon either of the other factors, leads to rapid exhaustion of the hepatic glycogen content. A third factor may be the surgical disease itself, especially if it be one with which inanition, hepatitis or circulating hepatotoxins are associated.

As preventive measures against the injurious effects of surgical anesthesia, proper preoperative dietary measures have been suggested during the past four decades by many experimental investigations and clinical observations. The studies of H. G. Wells,¹ Opie and Alford,² and E. A. Graham,³ to quote but a few representative examples, emphasized the importance of building rich hepatic glycogen reserves as a defense against liver injury by anesthetics,

This work was carried out with the aid of a grant from the Louis M. Monheimer Memorial Fund.

Whipple and his collaborators^{4, 5} demonstrated the efficacious protective effect of diets which are rich in protein and low in fat content

Appropriate preoperative dietary measures, in addition to protecting the liver against injury by anesthesia, help to counteract the ill effects of postoperative difficulties in the feeding of the patient. But regardless of how well the liver had been stocked with proteins and glycogen, the reserves are rapidly exhausted, hence it is necessary to resort to parenteral glucose feeding as soon as possible following operation in order to prevent hunger ketosis. This parenteral alimentation is necessarily linked with supplying the necessary amounts of water and electrolyte. The fluid and electrolyte requirements of the postoperative patient have been quantitatively elaborated by many workers. The same cannot be said in regard to parenteral glucose therapy. There are divergencies of opinion and practice, stemming in part from lack of appreciation of the quantitative factors involved, and in part from disregard of certain, pertinent physiologic laws. The studies reported here are concerned with the application in practice of these factors.

The amount of glucose needed in the postoperative period is decided by the purposes of its administration. Its primary purpose is to provide the liver with enough glycogen for the prevention of ketosis. Our studies have shown that on an average of 200 Gm. of glucose per 24 hours will serve this purpose providing that it is well spaced throughout the period. There are instances in which 150 Gm. of glucose will suffice, these are cases without appreciable liver damage and with adequate preoperative preparation. Again, there are instances when 200 Gm. of glucose per 24 hours is insufficient to forestall ketosis, these are the cases in poor nutritional state at the time of operation due either to inanition or to seriously impaired liver function. While the administration of 150 to 200 Gm. of glucose a day may suffice to prevent ketosis it will not supply the total energy requirements of the body, as a consequence undue quantities of protein will be consumed for fuel. By the simple means of increasing the glucose supply one can spare appreciable amounts of protein from being wasted in this manner with the additional advantage of preventing the inevitable formation of ketone bodies in the course of protein catabolism. Therefore, simply as a means of good physiologic economy, it is desirable to supply from 200 to 350 Gm. of glucose per 24 hours as a general rule. The upper limit applies to cases with known or suspected liver damage and to cases in which a poor nutritional state could not be remedied prior to operation.

The concentration of glucose solution to be employed is rather clearly defined by the quantitative requirements. To meet and yet not to exceed the postoperative fluid needs the necessary amount of glucose can be given only in solutions of not less than 10 per cent concentration. To meet the glucose requirement with less concentrated solutions would necessitate the administration of frequently excessive, and often prohibitive, amounts of fluid. It is a widespread view that 10 per cent glucose solution causes diuresis and thrombosis. Many, in holding this view, feel it mandatory to adhere to the use of

5 per cent solutions. Regardless of the validity of these objections, 5 per cent solutions often will not meet the physiologic needs. The amount of glucose being thus limited, ketonuria is in many instances virtually inevitable. An example to illustrate this fact is given in Table I.

The patient was a young woman in good health except for chronic cholecystitis with cholelithiasis, for which cholecystectomy was performed. There had been no episodes of biliary obstruction or clinical cholangitis. The patient, as indicated in Table I, was given 1500 cc. of 5 per cent glucose solution on the day of operation, and 2000 cc. daily during the ensuing two days. On the second postoperative day when oral feeding was attempted, the patient was nauseated sufficiently to preclude it. We suggested the possibility of ketosis, and a urine sample was found to show "three plus" acetone. We then suggested the administration of 2500 cc. of 10 per cent glucose solution.

TABLE I—*Showing a Case in which Ketosis Was Not Prevented by 5 Per Cent Glucose Solution, But Was Promptly Controlled by 10 Per Cent Solution*

Time After Start of Glucose Infusion Hours	Acetone (urine)	Amount of Glucose Infused
Nov 10	*	1500 cc 5% solution
Nov 11	*	2000 cc 5% solution
Nov 12	+++	2000 cc 5% solution
Nov 13 (prior to infusion)	+++	
10 20 a m	+++	2500 cc 10% solution started, infused over
11 30 a m	+	the course of the ensuing 7 hrs, beginning
12 30 p m	±	at rate of 250 cc /hr and gradually acceler-
2 30 p m	0	ating to 500 cc /hr during last 2 hrs
3 30 p m	0	
Nov 14		(Fed orally)

* Not tested

Since it is well known that starvation ketosis entails a diabetic condition, that is to say, impaired carbohydrate tolerance, it was further suggested that the infusion be started at a rate of 250 cc per hour and then gradually accelerated from hour to hour, until the rate should become 500 cc per hour during the sixth and seventh hours. After the onset of this procedure ketonuria rapidly decreased to "one plus" during the first, and to a trace during the second hour of infusion, and completely disappeared during the third hour. The precaution as regards the initial low rate of infusion was taken in order to prevent undue loss of glucose in the urine. During the second and third hours of the infusion, when the rate was slightly increased, there was a loss of 8 Gm. of glucose in the urine. Thenceforth there was no glycosuria despite a further increase in the infusion rate. By the time the infusion was completed the patient was amenable to oral feeding, and remained so throughout the postoperative course. We believe that it is fair to infer from these facts that the nausea and anorexia were due to ketosis. This ketosis was quite evidently starvation ketosis, which 2000 cc. of 5 per cent glucose solution daily failed to avert.

It is well recognized that ketosis can be the cause of more serious consequences than nausea and anorexia. More severe forms of ketosis may lead to acidosis, with ensuing depletion and derangement of the electrolyte pattern of the tissue cells. Such changes frequently induce smooth muscle spasm, which often is reflected in acute abdominal pain.⁶ An example of this phenomenon, from among our observations, is that of a patient following supravaginal hysterectomy. This patient was nourished postoperatively with amigen in 5 per cent glucose solution and small amounts of low caloric fluid by mouth. On the fifth postoperative day it came to our attention that the patient was beset by nausea, vomiting, and excruciating epigastric pain. Severe ketosis was suspected. A urine sample showed "four plus" acetone and "four plus" acetoacetic acid. Infusion of 2500 cc of 10 per cent glucose solution was recommended. As in the preceding case, the existent ketosis was quite likely to

TABLE II—*Showing that Infusion of 10 Per Cent Glucose Causes No Diuresis When Not Accompanied by Glycosuria*

10% Glucose Infused in 2 5 to 3 hr Period		Urine Excreted		Glycosuria Gm
Time of Start	Volume cc	Time	Volume cc	
Nov 9th				
3 40 a m	1000	From operation to 9 p m	175	0
		9 p m to 8 30 a m	450	0
Nov. 10th				
1 00 a m	1000	8 30 a m to 10 p m	480	0
8 00 a m	500			
	2500 cc intake		1105 cc output	
Nov 14th				
4 00 p m	1000	7 a m to noon	145	0
11 30 p m	1000	Noon to morning	800	Trace
Nov 15th				
3 00 p m	1000	7 a m to noon	100	Trace
		Noon to 5 p m	100	0
		5 p m to 7 a m	700	0
	3000 cc intake		1845 cc output	

have impaired carbohydrate metabolism, hence the glucose was administered over a period of six hours, starting at a slow rate which was then gradually increased. After the fourth hour of infusion ketonuria was completely obviated, and by its termination the patient was asymptomatic and able to eat. Recovery thenceforth was undisturbed and smooth.

With the description of these two cases we wish to stress the necessity of close observation for ketonuria throughout the preoperative, and the critical days of the postoperative periods, starting with the *very first* urine specimen obtained after the operation. Ketosis must be prevented, or if it emerges, it must be abolished at its very inception.

PARENTERAL GLUCOSE FEEDING

As regards the objections to 10 per cent glucose concentrations, first, we have not seen thrombosis any more frequently with this concentration than with weaker solutions

For glucose solutions of any concentration to induce diuresis it is obvious that glycosuria must first obtain Glycosuria is a consequence of excessive hyperglycemia which, in turn, is due to failure of the body to assimilate glucose at the rate at which it is infused

In contemplating the merits of the view that 10 per cent glucose solution induces diuresis we must divide operative patients into two groups the first comprising those with normal or near normal carbohydrate tolerance, and the second represented by known diabetics and such patients whose carbohydrate tolerance is lowered by the surgical disease or effects of the surgical

TABLE III—*Showing that Diuresis Caused by Infusion of 1000 cc of 10 Per Cent Glucose Is Insignificant Even When Moderate Hyperglycemia Occurs*

Patient Description	Time After Start of Infusion Hours	Blood Sugar (Venous Blood) Mg Per Cent	Urine	
			Volume cc	Sugar Gm
B M *	0	98		
Female, age 59, with minor fracture	0 5	248		
In apparent good health for age,	1	302	5	0 03
signs of generalized arteriosclerosis	2	337	50	0 4
apparent	Infusion ended			
	3	101	190	1 0
	4	65	70	0 4
J K **	0	88		0
Female, age 47, with toxic hepatitis	0 5	225	70	0 2
(proven by liver biopsy)	1	313	120	0 6
	2	379	150	1 2
	Infusion ended			
	3 5		260	2 6
	4 5		50	0 3
	5 5			

* 800 cc of 10% glucose, administered at constant rate in the course of two hours (40 Gm glucose per hour)

** 1000 cc of 10% glucose, administered at constant rate in the course of two hours (50 Gm glucose per hour)

procedure In the first group, the production of diuresis by 10 per cent glucose solution is not possible so long as the rate of infusion does not exceed 50 to 60 Gm of glucose per hour This fact was first demonstrated by Woodyatt⁷ who showed that, on an average, 0.85 Gm of glucose per kilo bodyweight per hour can be administered intravenously to a healthy person without the production of glycosuria This means that an average individual of 70 kilo bodyweight, whose carbohydrate tolerance is normal, does not develop abnormal hyperglycemia leading to glycosuria when glucose is administered intravenously at a rate of 600 cc of 10 per cent solution per hour And without glycosuria, no diuresis can result from such infusion Besides,

in order to allow a safety margin, one should use a somewhat lower rate of infusion, as for example, 2.5 to 3 hours for 1000 cc of solution. In Table II is presented an example in which under such conditions, no diuresis takes place.

But even when the infusion of 10 per cent glucose solution entails mild degrees of glycosuria, due to unforeseen impairment of the glucose tolerance, diuresis is still absent. This is clearly illustrated by the two examples recorded in Table III.

The glucose in these two instances was infused at rates of 40 and 50 Gm per hour, respectively, and the urine was collected by catheterization during the infusion and for two and two-and-a-half hours after its termination. From the data in Table III it is evident that there was retention of fluid rather than diuresis, although the blood sugar in both cases rose well above 300 milligrams per cent and small amounts of glucose were excreted in the urine.

It is a significant fact, however, that the glucose tolerance of many patients is more or less impaired in the postoperative state. This condition may be of transitory nature, as proved in the course of our studies by entirely normal response to the conventional glucose tolerance test following surgical convalescence. In other instances we found distinct, though not severe, forms of diabetes which were not diagnosed before the operation probably because the disease was in an early stage in which glycosuria occurred only intermittently and was completely absent on a balanced hospital fare. Such latent diabetes is greatly exacerbated in the course of major surgical treatment and is subject to further degeneration if ketosis is allowed to develop.

These observations explain why we came upon considerable degrees of glycosuria when the rate of glucose infusion was as low as 30 Gm per hour, although the patient was not diagnosed as diabetic. And it was such observations that led us to collect—as a regular routine—urines during and following parenteral glucose administration for the quantitative determination of glucose. While so doing we found instances in which 25 per cent to 50 per cent of the glucose was lost when infused at the rate of 50 to 60 Gm per hour. Part of the glucose may be lost even when infused at the rate of 25 Gm per hour in the form of 5 per cent solution. And this is exactly the condition in which the patient can least afford to lose any of the glucose supplied him. Furthermore, this is the condition in which glucose does cause diuresis. Thus, the actual problem is to infuse the glucose at a rate which is within the assimilatory power of the patient, regardless of whether it is given in 5 per cent or 10 per cent solution. The infusion may be too fast in relation to the tolerance of the patient even if a 5 per cent solution is used, and an appropriately low rate of infusion may be observed when using a 10 per cent solution.

The answer to the problem, then, is to infuse the glucose at a rate which is not in excess of the rate of assimilation. This does not mean, as might at first seem apparent, that the infusion must be extended over five or six hours when glycosuria indicates a low rate of assimilation. In most instances it is only necessary to keep the rate low during the first hour or even half-hour,

following which it can be safely increased to a rate of 50 Gm per hour. This rule is based upon a well known physiologic law. Staub⁸ and others have observed that if two doses of glucose are administered orally at one hour intervals, the second dose incites considerably less hyperglycemia than the first. This phenomenon is due to the fact that the hyperglycemia produced by the first dose stimulates the assimilatory mechanism,* with the result that the second dose of glucose is utilized at a much higher rate than the first.

TABLE IV—*Showing the Increase in the Rate of Assimilation Under the Stimulus of Hyperglycemia*

Time After Start of Infusion Hours	Venous Blood Sugar mg %	Glucose in Extracellular Fluid* Gm	Increment in Extracellular Fluid Gm	Glucose Infused Gm	Glucose Excreted Gm	Glucose Assimilated Gm	Assimilation rate Gm /hr	Remarks
0	98	13.7						Case 1 Wt 54.5 kilo
0.5	248	27.8	14.1	20	0	5.9	11.8	Infusion of 80 Gm glucose at the rate of 40 Gm /hr
1	302	33.8	6.0	20	0.4	13.6	27.2	
2	310	34.7	0.9	40	1.0	38.1	38.1	
3	88	9.8	-24.9	0	0	24.9	24.9	
4	65	7.3	-2.5	0	0	2.5	2.5	
0	91	19.1						Case 2 Wt 84 kilo
0.5	195	32.8	13.7	20	0	11.3	22.6	Infusion of 100 Gm glucose at the constant rate of 50 Gm /hr
1	231	38.6	5.8	25	1.3	17.9	35.8	
2	204	42.8	4.2	50	0	45.8	45.8	
3	74	12.4	-30.4	0	0	30.4	30.4	
4	78**	13.1	0.7	0	0	-0.7	-0.7	
0	89	16.0						Case 3 Wt 72 kilo
0.5	165	23.8	7.8	14	0	6.2	12.4	Infusion of 100 Gm glucose at the rate of 28 Gm in first hour, 72 Gm in second hour. Perspired freely, felt "shaky" one hour after termination of infusion
1	150	21.6	-2.2	14	0	16.2	32.4	
2	180	25.9	4.3	72	0	67.7	67.7	
3	60	8.6	-17.3	0	0	17.3	17.3	
4	81**	11.7	3.1	0	0	-3.1	-3.1	

* Free glucose is confined to the extracellular fluids, including the whole blood. There is no free glucose in the cell content since the cells assimilate glucose only after its conversion into glucose phosphate. The distribution of glucose in the extracellular fluid is not quite even. The concentration is highest in blood plasma, in the corpuscles it is 15 to 20 per cent lower. We have estimated the average glucose concentration in the total extracellular fluid as roughly 20% lower than in the blood. We have taken the total amount of extracellular fluid as 25% of the total bodyweight. By use of these figures and knowing the venous blood sugar value, the amount of glucose in the extracellular fluid was calculated. From this knowing the amount of glucose infused and the amount lost in the urine in a fixed period of time, the amount of glucose assimilated was determined.

** The increase in blood sugar (glucose in extracellular fluids) is a compensatory response to hypoglycemia. This glucose is produced by dissimilation (phosphorylation with subsequent dephosphatization) of hepatic glycogen.

This law is equally valid, as we have observed in many experiments, when glucose is administered parenterally. In Table IV, three cases are presented which demonstrate this fact.

CASE REPORTS

Case 1 is a 63-year-old woman with an essentially negative past history, hospitalized for a relatively minor fracture, there were moderate evidences of generalized

arteriosclerosis. An intravenous infusion of 10 per cent glucose solution was given the patient at the constant rate of 40 Gm per hour. As may be seen, the assimilatory rate (Gm/hr) was 11.8 in the first half hour, 27.2 in the second half hour, and 38.1 in the second hour of infusion. In Case 2, a robust man of 23 years with acute cellulitis of the face, a similar infusion was administered at the constant rate of 50 Gm per hour. The rate of assimilation (Gm/hr) was 22.6 during the first half hour, 35.8 during the next half hour, and to 45.8 during the second hour. Both of these cases show an impaired glucose tolerance, as indicated by the blood sugar values determined in the venous blood.

Case 3 (Table IV) is a robust, healthy man of 21 years, who showed no evidence of impaired carbohydrate metabolism. His only pathology was a very minor fracture, and he seemed suitable for the subject of an experiment to demonstrate more emphatically the acceleration of the assimilatory mechanism under the stimulus of hyperglycemia. He was given an intravenous infusion of 10 per cent glucose solution at an initial rate of 28 Gm per hour, the rate being increased to 72 Gm per hour at the beginning of the second hour. As may be seen in the table, assimilation of the glucose started rather sluggishly, so that only 6.2 Gm of glucose was assimilated in the first half hour (12.4 Gm/hr) and the venous blood sugar reached a level of 165 mg per cent. Under the stimulus of this hyperglycemia the rate of assimilation rose to 32.4 Gm/hr in the second half hour, while in the second hour, when the glucose was being infused at a rate almost treble that of the first hour, the assimilatory rate was doubled to 67.7 Gm/hr, and the venous blood sugar rose only to 180 mg per cent.

These observations prompt a quantitative procedure for the administration of glucose. The intravenous infusion of 10 per cent solution is begun at a slow rate (20 to 25 Gm) and accelerated to 50 to 60 Gm per hour after the first half hour at which rate it is continued until completed. All urine specimens obtained during, and for several hours following, infusions are quantitatively analyzed for sugar content by a simple method which requires no more skill and time than that necessary for the adequate execution of a qualitative test.⁹ In those patients who, at any time, show more than minimal glycosuria, and in those who are suspected of markedly depressed glucose tolerance due to any of the causes previously discussed, serial, quantitative urine sugar determinations are made at frequent intervals during the course of infusion, and the rate of infusion not accelerated until there is no, or negligible, glycosuria.

Moderate glycosuria, which represents less than 10 per cent of the infused glucose, does not invite serious misgivings as to the correctness of the procedure. It still represents fair economy and, as shown in Table III, does not entail diuresis. It is always desirable, however, to determine quantitatively the extent of glycosuria during and for two hours after the infusion in order to ascertain that there be no undue waste of glucose.

If the loss through glycosuria amounts to 10 per cent or more of the glucose infused, despite the precautions just described, the use of insulin is

* The term "assimilation" is used here to denote the process of incorporation of blood sugar into the cell content. This process is contingent upon the phosphorylation of glucose, since cells are impermeable to free glucose. The phosphate esters of glucose are then either oxidized in the cells or polymerized to glycogen for storage. The latter processes, however, are not part of the process of assimilation, the former is a storing process, the latter catabolism.

indicated. The same holds, of course, for diabetic patients. Insulin in these cases is of great service, but can do as much harm as good if it is not governed by due consideration to certain physiologic principles. We intend to discuss this aspect of the problem in a separate note.

SUMMARY

- 1 The purpose of postoperative parenteral glucose therapy is two-fold: prevention of starvation ketosis, and exertion of its protein-sparing effect.
- 2 This dual purpose can be achieved with amounts of glucose no less than 200 to 350 Gm., well spaced over the 24 hours.
- 3 Such amounts of glucose, if they are administered in solutions of less than 10 per cent concentration, make the total amount of fluid excessive, and often prohibitive. The concentration of the glucose solution, therefore, must not be less than 10 per cent.
- 4 The view that 10 per cent solutions necessarily cause diuresis is erroneous. If the solution is infused at proper rates, in keeping with the rate of assimilation, excessive hyperglycemias and consequent glycosurias are precluded and hence diuresis does not occur.
- 5 A rational procedure of intravenous glucose infusion entails an initial low rate of infusion of 10 per cent solutions (in combination with Ringer's solution or physiologic saline if desired), with subsequent acceleration of the rate. Serial quantitative determinations of urine sugar show whether or not the rate of infusion exceeds the rate of assimilation and thus serve in guiding the regulation of the rate of infusion.

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DISASTERS FOLLOWING THE OPERATION OF LIGATION AND RETROGRADE INJECTION OF VARICOSE VEINS

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THE OPERATION of high ligation and retrograde injection of the saphenous vein has become the treatment of choice in those cases of varicose veins showing evidence of retrograde flow. This appears to be a rational method for, in the presence of incompetent valves, the weight of the column of blood from the femoral ring to the ankle interferes with venous return in the lower leg, and leads to pooling of blood in the large varicose veins.

It appears to be the belief of the occasional operator that this is a simple, easily carried out procedure, free from hazard. Consequently, the operation is widely practised by inexperienced surgeons and hospital internes.

As might be expected unfortunate results are occurring with increasing frequency. The purpose of this paper is to report 21 such cases, and, from a study of the results, to offer suggestions which might decrease the incidence of complications. It is quite obvious that minor surgical complications, such as haematomata and infections, will occur in a percentage of these cases depending on the care and skill with which the operation is carried out. However, we wish only to discuss the serious disasters such as occlusion of the artery by operative trauma, deep femoral phlebitis, and, perhaps, those more frequently unfavorable results due to damage caused by sclerosing solutions. It should also be mentioned that all these adverse results happened not only to occasional, or junior, operators, but also to senior surgeons of great experience and high standing.

The operation of ligation of the great saphenous at the saphenofemoral junction may be difficult in an obese individual with a thinned out varix near the terminal portion, especially if, due to previous phlebitis and periphlebitis, firm adhesions are present. The varix is easily torn, or one of the large branches may escape the ligature. It should be appreciated that very little pressure is required to stop this flow of blood but, at the moment, the unexpected severity of the bleeding upsets the calm of the surgeon and uncontrolled clamping results in injury to the deep femoral vein, the artery or the nerve.

Case 1—While freeing a large varicose saphenous vein a large tributary was torn near the terminal portion. Kelly clamps were hurriedly applied which, on later investigation, proved to have included the femoral vein necessitating its ligation. When last seen some months later marked oedema of the leg was present. This patient, a soldier, had to be re-categorised and returned to base duties. On discharge he was found to be pensionable because of this permanent disability.

Case 2—This patient was operated upon, under local anaesthesia, by a skilled surgeon in charge of a varicose vein clinic, in the Outdoor Department of a large teaching hospital. She was obese, a known hypertensive, and an electrocardiograph had shown evidence of myocardial degeneration. Her veins were large, troublesome and showed valvular incompetence. The past history revealed an episode of phlebitis. At operation, a large varix was present at the saphenous junction, adherent to the adjacent tissues. While dissecting this free, the saphenous was torn at its femoral junction. Severe hemorrhage occurred which could not be arrested by careful clamping. Finally, bleeding was controlled by pressure while a blood transfusion was given and a general anesthetic commenced. An enlarged incision was made to allow dissection of the femoral vein, which was ligated. However, the patient went into shock, and, in spite of blood transfusion, died half an hour later. Autopsy showed no lesion to account for her death, so it must be presumed that this severe hemorrhage overtaxed a damaged cardiovascular system, with fatal result.

After such an accident it is easy to point out how the hemorrhage could have been more safely handled, for example, by the use of packing and a pressure bandage, but these emergencies occur quickly and become frightening to the surgeon, who usually makes every effort to arrest the bleeding by clamping the bleeding point.

In this presentation no example of ligation of the femoral vein with retrograde injection of sclerosing fluid is included, but when it is realized how superficial the femoral vein is in the inguinal region, it is easy to imagine that the saphenous may be considered as a tributary rather than as the main vein, and the femoral ligated and injected in consequence. Such an accident would certainly result in a marked oedema, and later in a so-called postphlebotic leg.

Case 3—This patient had had a previous ligation and injection of the saphenous vein with recurrence of varicosities. A surgeon, with considerable interest and experience in the treatment of varicose veins, elected to explore the saphenofemoral junction. The adhesions from the former operation made the procedure difficult but, presumably, the vein was found, ligated and distally injected with sodium morrhuate. Immediate pallor and paresis of the leg occurred. When the wound was reopened, it was found that the femoral artery was ligated, divided and distally injected. In spite of palliative treatment, a mid-thigh amputation was required.

Case 4—A young woman underwent ligation and injection of the saphenous, under local anesthesia. When the vein was injected, severe pain occurred from the groin to the toes, the leg blanched, and no arterial pulsation was obtainable. This patient was seen by one of us in consultation. The leg was found to be cold, blanched, exceedingly sensitive and pulseless. Subsequent gangrene necessitated a mid-third thigh amputation. Histological examination showed thrombosis of the major arteries. The surgeon stated that the vessel he ligated did not pulsate, but it is well recognized that a state of spasm often occurs in a vessel on exposure and handling which minimizes pulsation. In this case, the original wound was not explored. The young, but well-trained, surgeon is now defending a lawsuit for very large damages and has suffered a serious setback in his career.

Case 5—This patient underwent bilateral saphenous ligation and injection. Eight cc of sodium morrhuate solution were injected into both veins. Considerable pain was felt in the left thigh after the operation. The veins were well thrombosed and the leg arteries were noted to be pulsating normally on discharge three days later. A month later, she was readmitted with a sloughing, gangrenous, foul-smelling ulceration, five

inches in diameter, in the left upper posterior aspect of the thigh. Bacterial study revealed anaerobic streptococci as the predominant organism. On excision, it was found that the gangrenous slough involved the surface of the femur, included the sciatic nerve, and extended into the perineum. Amputation was considered but refused. The femur has now regenerated and the wound has healed but sciatic paralysis remains. The Wassermann is negative, the blood sugar curve is normal, and arterial circulation has always been adequate. This operation was carried out by a senior surgeon of great experience and there seems little possibility that any technical error occurred. The area of tissue necrosis corresponds to the distribution of the profunda femoris artery, and it has been suggested that the complication was due to spasm of this artery. There are many objections to this explanation.

Case 6—This patient underwent a high and low ligation of the right saphenous, under general anesthesia. Sodium morrhuate was injected at the time of operation. The patient was confined to bed for three days because of fever. Six days after the first operation the left saphenous was ligated and injected. Because of fever the patient was again confined to bed. Six days later, still febrile, she complained of a tight feeling in the chest, general malaise and a dry cough. A chest roentgenogram revealed a shadow suggestive of pneumonia at the right base. A second acute episode occurred eight days later. One month following her second operation she died suddenly. Autopsy showed thrombosis of all the great veins of the left leg extending up to the inferior vena cava, with healing infarcts in the lower lobe of the right lung, and massive recent emboli filling the pulmonary artery.

Case 7—This patient, a young woman, died suddenly at home, a week after ligation and injection of the left saphenous vein, presumably from a pulmonary embolus.

Case 8—This patient had bilateral saphenous ligation. Four days later, daily injections of calf varices with 2 cc of sodium morrhuate were begun. He was discharged two weeks later but developed a pulmonary embolus shortly after leaving the hospital. Two further emboli occurred associated with bilateral pleural effusion. The patient had bilateral thrombophlebitis. He was discharged from the Army, and when recently examined showed bilaterally swollen, aching legs, with medial supramalleolar ulcers. In this case, the saphenous veins having been ligated, the phlebitis presumably occurred in the deep femoral vein.

In all, information has been received of four fatalities and ten further cases of deep thrombophlebitis following ligation and injection of saphenous veins.

The cases of deep thrombophlebitis all have permanent disability, some with persistent oedema, eczema and ulceration of the leg. The cases which occurred in the Services will all be pensionable.

It may be true that operative accidents, as described above, are comparatively rare. Two other cases of femoral artery ligation are known to the authors, but not reported here because of insufficient data. What has been reported, however, should be sufficient to show the hazards of saphenous ligation and retrograde injection, and to emphasize the difficulties the procedure may present to the surgeon. In order to save beds, many hundreds of these cases have been done in the outpatient clinic of the Royal Victoria Hospital in the Varicose Vein Clinic, under local anesthesia. This procedure, except for the death reported previously, has proved satisfactory,

especially as immediate ambulation appears to be of great value. However, certain rules have had to be laid down. Adequate operating room equipment and nursing staff must be available, together with an assistant of some experience. The operation can only be carried out when the senior surgeon in charge of the clinic is in attendance in the outpatient clinic. In the event of any unusual complication the advisability of admitting the patient, or of immediately calling one of the senior consultants, must be considered. The surgeon must be familiar with the anatomy of the saphenous vein (and especially its tributaries), the fossa ovalis and its relation to the deep fascia, and also the relationship of the saphenous to the femoral vein and artery. A useful anatomic consideration is the fact that the superficial external pudendal artery, though occasionally variable, runs on the lower superficial edge of the fossa ovalis posterior to the incurving saphenous vein. It is, therefore, a good guide to the sapheno-femoral junction. After incising the skin, one should feel carefully for the pulsation of the femoral artery, so that adequate orientation may be achieved. Dissection must be meticulous. In this way will the operative hazards be reduced to a minimum.

If the main vein is torn, blind clamping is dangerous. The bleeding is venous, of low pressure, and can easily be controlled by the finger or by packing. Lowering the head of the table still further lessens the pressure. For this reason it is a wise precaution to fix shoulder rests on the table before operating. Suction apparatus should always be immediately available in case of bleeding. Careful removal of the packing after several minutes with the use of suction to keep the wound free of blood, usually shows the point of bleeding which can be delicately clamped. Ligation of the femoral vein, which has usually been torn, is then indicated.

It is still open to question whether primary femoral arterial thrombosis can occur as a result of saphenous vein ligation and injection. It appears possible, however, that transient arterial spasm may result. The authors have observed five such cases out of 756 operations carried out under local anesthesia. In these cases greater pain than usual occurred in the leg immediately following operation. The pain was of a burning cramp-like character. In three cases the pain radiated to the lumbar region and necessitated temporary discontinuance of the operation. The leg blanched and no pulsation could be felt in the involved foot. The pain disappeared in thirty minutes. The only reasonable explanation appears to be that operative trauma, adjacent to the femoral artery, produced spasm sufficient to arrest the blood flow for half an hour.

The majority of accidents are due to deep venous thrombosis and embolism. When large quantities of sclerosing solutions are injected into an incompetent vein some of the fluid is apt to enter the deep system through communicating branches. Every surgeon has noted the complaint of the patient of a bitter taste in the mouth, or of an abdominal cramp following the injection of 2 cc. of quinine urethane into an incompetent superficial varicosity. Presumably, this fluid has passed into the deep venous circulation, and been

absorbed. Perhaps this phenomenon is illustrated in that considerable group of patients who show persistent oedema following saphenous ligation and injection. In the rare cases who die of embolism, other unsuspected factors may be present, for example, an increased clotting tendency, the use of a larger amount of sclerosing solution than is usually advised, or prolonged post-operative inactivity.

The authors have collected 16 accidents due to thrombosis, but as these cases have been seen not only in our own hospital but also in the Services and in consultation, no percentages can be arrived at. Perhaps this is just as well for the percentage would be low enough to give the surgeon a feeling of safety, but as the widow said, "The percentage might as well be 100 per cent as far as my husband and I are concerned." Of the 16 cases referred to, with deep venous thrombosis following ligation and injection, four produced fatal pulmonary embolism, and two developed minor emboli.

Against the facts of this report must be weighed the knowledge that the ligation and retrograde injection treatment of varicose veins appears to be the best yet evolved. It is not our wish to discredit it. We have observed that the thrombotic accidents all occurred in patients who did not walk for 12 hours or more following operation. In several cases general or spinal anesthetics had been used which delayed walking for several hours. It is suggested, therefore, that only a local anesthetic be used, and that patients walk immediately after operation. Further, it was noted that in all these cases more than 6 cc of sclerosing fluid were used. It is suggested that no more than 5 cc of any sclerosing solution be injected at the time of operation. Experience may finally show that ligation alone should be carried out, with later injections once a week until the varicosities have been obliterated.

In a series of 756 ligations and injections, mostly on outpatients, under local anesthesia, who walked immediately after operation and for 15 minutes every hour following operation with active dorsi—and plantar flexion of the foot as soon as the sclerosing solution had been injected, we have had no case of embolism. Early ambulation is designed to ensure a rapid flow of blood in the deep venous system. In none of these cases has more than 6 cc of 5 per cent sodium morrhuate been injected, and, by drawing back blood into the syringe, this amount has been diluted three to one with blood before injection. One death occurred as reported above (Case 2) due to actual operation. One case had a deep phlebitis, treated by subsequent ligation of the superficial femoral vein.

If an embolus should occur, we advocate removal of the clot in the vein with ligation of the superficial femoral vein. This appears safer than the use of dicoumarol, but, if ligation is not feasible, dicoumarol in adequate doses should be given, controlled by frequent estimations of the prothrombin time. Again, it should be emphasized that this report is not intended to discourage the use of the operation of ligation and injection of the saphenous vein for varicose veins with incompetency, but to warn of the dangers and offer a few suggestions as to how these dangers may be overcome.

SUMMARY

1 This paper is presented to emphasize the increasing number of untoward results following the operation of ligation and retrograde injection of varicose veins. Twenty-one such cases are referred to.

2 These disasters belong to two main groups, those resulting from operative difficulties and mistakes, and those resulting from deep venous thrombosis subsequent to operation. The latter group is the larger.

3 Study of the thrombotic group shows that two factors probably play a considerable role in the formation of this thrombosis. These are lack of muscular activity of the legs following operation, resulting in a slowing of the deep venous return, and the use of too great a quantity of sclerosing fluid.

4 Suggestions are made with a view to preventing the disasters of both the operative and the thrombotic groups.

SACROCOCYGEAL CHORDOMA

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CHORDOMA, though a rare tumor, is encountered often enough to require consideration, particularly in a tumor clinic where there are other types of neoplasms from which it must be differentiated. For those interested in oncology a knowledge of the clinical course, diagnosis and prognosis of chordoma as well as its response to various therapeutic methods is important. This study is based on an analysis of seven cases observed and treated at the Memorial Hospital from 1930 to 1943, inclusive, in addition, 128 previously reported cases have been reviewed.

Definition. Chordoma is a specific tumor arising from the remnants of the primitive notochord. It is characterized by slow growth which is inexorably progressive, a tendency to invade and destroy bone by direct extension, local recurrence after surgical excision and slight or negligible regression following irradiation. Occasionally chordoma is capable of regional and distant lymph node and visceral metastases.

Historical Summary. Attention was first called to chordoma in 1856 by Virchow⁹³ who described small tumor-like masses at the spheno-occipital synchondrosis. It was Virchow's belief that this tumor was essentially cartilaginous in nature and he called it *ecchondrosis* (from cartilage) *physaliphora* (vacuole containing cell). Two years later Muller⁶⁴ suggested that there was a relationship between this growth and the chorda dorsalis and accordingly introduced the term chordoma (chordoid tumor). It was not until 1894 that the true nature of this neoplasm was definitely established by Ribbert⁷⁸ who reported five cases of his own. This author carried out extensive morphologic investigations and the evidence which he accumulated supported Muller's notochordal origin of chordoma. In addition, Ribbert is credited with demonstrating the derivation of chordoma from notochordal remnants by puncturing the nucleus pulposus in rabbits and producing a tumor which was supposed to be grossly and microscopically identical with chordoma. The first case of sacrococcygeal chordoma was described in 1900 by Henning⁴² who encountered this tumor while performing a postmortem examination on a seven-months-old stillbirth.

Although several comprehensive reviews of the literature have been published by Stewart, Mabrey, and others, most of the reports have been based on personal experience with only a single or a few cases. Aside from the

present report, only three clinical pathologic studies have been made based on a relatively large series of chordoma in the sacrococcygeal region, namely, that of Seneque and Grinda (8 cases), Fletcher, *et al* (10 cases), and Mabrey (8 cases). In a complete review of the literature on sacrococcygeal chordoma we found only 128 reported cases, or a total of 135 including the seven reported by us.

Incidence It is difficult to determine with accuracy the incidence of chordoma since it occurs so rarely. During the period from 1930 to 1943 inclusive, 31,099 cases of cancer were seen at Memorial Hospital (first admission) and among these were only seven cases of sacrococcygeal chordoma and two of the spheno-occipital type.

Age Although chordomas may occur at any age, they are usually encountered in about the 5th decade of life. Of the 128 cases reported in the literature (Table I), the youngest patient was three months old, the oldest 78 years of age, and the median age was 46 years. In the series herein reported (Table II), the youngest patient was 50 years and the oldest 70 years of age, the median age was 60 years. It is likely, however, that chordoma arises at a much earlier age than these figures reveal for an analysis of our own and previously reported cases shows that there is an average interval of about three years between the onset of symptoms and hospital admission. Even the age of the onset of symptoms is not a reliable index of the date of origin of the tumor for chordoma is admittedly slow growing and in all likelihood arises many years before the appearance of clinical manifestations.

Sex Sacrococcygeal chordoma is encountered more often in male than in female patients. In the present series of seven cases there were five males and two females and of the 128 patients reported in the literature 68 per cent were males. The significance of the predominance of males is difficult to evaluate, but there is no evidence to support the thesis that this neoplasm might be considered one of the sex-linked tumors.

ETIOLOGY

Trauma The question of trauma as an etiologic factor in the production of certain anatomic forms of cancer is complicated and highly controversial. A recent excellent review of this subject by Stewart⁸⁶ indicates that, at least in the human, single or multiple injuries, especially in the case of a bone tumor, cannot be seriously regarded as a significant factor in the etiology of neoplasms. Although Ribbert was supposed to have produced experimental chordoma in the rabbit by puncturing the nucleus pulposus, his work is inconclusive and has never been confirmed. A history of trauma was obtained in two of our seven cases, and of the previously reported cases of sacrococcygeal chordoma in the literature, definite trauma to the lower end of the spine was recorded in 32 per cent. It is our conclusion that the relationship of injury to the onset of this neoplasm remains unproven.

Development Anatomy The anatomic origin of the notochord has never been definitely established. We do know, however, that at an early period of

TABLE I—*Sacro-Coccygeal Chordomas* Cases Collected from the Literature

No	Author	Year	Sex	Age	History of Trauma	Histol Diagn Section-Aspiration	Duration of Symptoms	Treatment			Metastasis	Survival Period	End Result
								Radia- tion	Surgery	Recur- rences			
1	Henning	1900	M	7 mos	No	Section	?	No	Yes	Yes	No	1 year	?
2	Mazzia	1910	M	54	No	Section					No	7 months	
3	Feldman	1910	M	46	No	Section	1 year	No	Yes	Yes	No	2 years	?
4	Wagner	1910	M	68	No	Section	6 years	No	Yes	Yes	Lymph nodes	1 year	?
5	Curtis	1911	M	58	No	Section	6 months	No	Yes	Yes	No	2 years	Dead of disease
6	Wood	1913	F	35	No	Section	?	No	Yes	Yes	No	4 years	?
7	Dibbernardi	1913	M	56	No	Section	2 months	No	Yes	?	No	?	?
8	Albert	1915	M	26	Yes	Section	3 months	No	Yes	Yes	No	14 months	Dead of disease
9	Tuffier & Vignes	1918	F	55	No	Section	3 years	No	Yes	Yes	No	3 years	?
10	Lund	1919	F	60	No	Section	3 years	No	Yes	Yes	No	1 year	Dead of disease
11	Pototschning	1919	M	40	No	Section	10 years	No	Yes	Yes	Lymph nodes	2 months	Died postoperatively
12	Peters	1919	M	68	No	Section	5 years	No	Yes	Yes	Lymph Nodes	?	Dead of disease
13	Wiethold	1920	M	61	No	Section	?	No	Yes	?	?	?	?
14	Lewis	1921	M	54	Yes	Section	?	?	?	?	?	?	?
15	Lewis	1921	M	30	No	Section	?	?	?	?	Lymph nodes and liver	?	Dead of disease
16	Lewis	1921	M	58	No	Section	2 years	No	Yes	?	Lymph nodes	?	?
17	Lewis	1921	F	22	No	Section	2 years	No	Yes	Yes	Lymph nodes	1 year	Dead of disease
18	Stewart	1922	M	65	No	Section	8 years	No	Yes	Yes	Pertoneum	11 years	Dead of disease
19	Linek	1922	M	61	No	Section	2 years	Yes	Yes	Yes	Skin and sub-cutaneous tissue	?	?
20	Mieotti	1922	M	53	Yes	Asp biopsy	?	No	Yes	Yes	No	6 months	Dead of disease
21	Beard et al	1922	M	22	Yes	Section	1 year	Yes	Yes	Yes	No	1 year	Dead of disease
22	Pool	1922	F	65	No	Section	2 years	No	Yes	Yes	No	6 months	Dead of disease
23	Andler	1923	M	45	Yes	Section	3 months	No	Yes	Yes	No	?	?
24	Andler	1923	M	62	No	Section	5 years	No	Yes	Yes	No	1 year	Dead of disease
25	Hirsch & Ingalls	1923	M	54	No	Section	1 year	No	Yes	No	No	3 years	Dead of disease
26	Rauli	1924	M	49	No	Section	6 months	No	Yes	Yes	No	?	Dead of disease

CHORDOMA

TABLE I—(Cont'd) Sacro-coccygeal Chordomas Cases Collected from the Literature

No	Author	Year	Sex	Age	History of Trauma	Histol Diagn Section-Aspiration	Duration of Symptoms		Treatment		Recur- rences	Metastasis	Survival Period	End Result
							Symptoms	?	Radiation	Surgery				
27	Arguad	1925	F	14 mos	No	Section	6 months		No	No	No	Liver	?	
28	Walz	1925	M	62	No	Section	1 year		No	Yes	No		1 year	Dead of disease
29	Hayman	1925	F	60	No	Section	3 years		No	Yes	No		2 years	?
30	Young	1925	M	49	No	Section	6 months		No	Yes	Yes		6 months	?
31	Argaud	1925	F	18	Yes	Section	7 months		No	Yes	?		?	?
32	Richardson & Taylor	1926	M	43	No	Section	6 months		No	Yes	No		1 year	Dead of disease
33	Kersner	1926	M	45	No	Section	2 years		No	Yes	?		2 years	?
34	Sommer	1926	M	56	No	Section	?		No	Yes	?		6 months	?
35	Andler	1926	F	57	No	Section	2 years		No	Yes	?		?	?
36	Andler	1926	M	50	Yes	Section	3 months		No	Yes	?		?	?
37	Andler	1926	M	49	No	Section	2 years		No	Yes	?		?	?
38	Stewart & Morin	1926	M	58	No	Section	6 months		Yes	Yes	?		?	Dead of disease
39	Alexander & Struthers	1926	M	64	No	Section	1 year		Yes	Yes	Yes		?	?
40	Cameron	1926	F	59	No	Section	6 months		No	Yes	No		?	?
41	Kwartun & Stewart	1927	M	56	No	Section	1 year		No	Yes	No		1 year	Dead of disease
42	Letulle & Dujarier	1927	M	32	No	Section	6 months		No	No	No		1 year	Dead of disease
43	Revnes & Rouslacron	1927	M	68	Yes	Section	1 year		Yes	No	No		33 years	?
44	Fumegalli	1927	F	68	No	Section	5 months		Yes	Yes	No		1 year	?
45	Bustos	1927	M	67	Yes	Section	?		Yes	?	No		6 months	?
46	Podilna & Pavlica	1928	F	44	No	Section	3 years		No	Yes	?		?	?
47	Conway	1929	F	20	No	Section			Yes	Yes	No		?	?
48	Templesky	1929	M	52	Yes	Section			No	Yes	No		?	Dead of disease
49	Hutton	1929	M	49	Yes	Section			No	Yes	No		?	?
50	Michulko & Rochlin	1930	M	57	No	Section	2 years		Yes	No	Lymph nodes		2 years	Dead of disease
							3 years		Yes	No	Peritoneum		?	Dead of disease
							6 months		Yes	No	Muscle		?	Dead of disease
							6 years		Yes	No	Bladder		?	Dead of disease
									Yes	No	Omentum		?	?
									Yes	Yes	No		10 months	?
									Yes	Yes	No		3 years	?
									Yes	No		16 years	?	Dead of disease

TABLE I—(Cont'd) *Sacro-coccygeal Chordomas* Cases Collected from the Literature

No	Author	Year	Sex	Age	History of Trauma	Histol Diagn Section-Aspiration	Treatment				Survival Period	End Result
							Duration of Symptoms	Radiation	Surgery	Recurrences	Metastasis	
51	Gerber	1930	M	55	No	Section	2 years	No	Yes	Yes	No	Dead of disease
52	Seneque & Grinda	1930	F	60	Yes	Section	1 year	No	Yes	Yes	No	?
53	Seneque & Grinda	1930	M	39	Yes	Section	2 years	Yes	No	Yes	No	?
54	Seneque & Grinda	1930	M	56	No	Section	6 months	Yes	No	Yes	No	?
55	Seneque & Grinda	1930	M	78	Yes	Section	6 months	Yes	No	Yes	No	Dead of disease
56	Seneque & Grinda	1930	M	32	Yes	Section	?	Yes	No	Yes	No	Dead of disease
57	Seneque & Grinda	1930	M	63	No	Section	?	Yes	Yes	Yes	No	Dead of disease
58	Seneque & Grinda	1930	F	68	No	Section	2 years	Yes	No	Yes	No	Dead of disease
59	Seneque & Grinda	1930	F	53	No	Section	?	Yes	Yes	Yes	No	?
60	Willis	1930	F	36	No	Section	2 years	No	No	Yes	Spleen liver lung heart kidney skin thyroid	Dead of disease
61	Dickson	1931	M	41	No	Section	10 months	Yes	Yes	Yes	No	?
62	Wildbolz	1931	M	52	Yes	Section	2 years	Yes	Yes	Yes	No	Dead of disease
63	Sandahl	1932	M	23	No	Section	5 months	Yes	Yes	Yes	No	Dead of disease
64	Wahling	1932	M	56	Yes	Section	3 years	No	Yes	Yes	No	Dead of disease
65	Stanton	1932	M	62	Yes	Section	2 years	Yes	Yes	Yes	No	?
66	Estella	1932	F	3	No	Section	3 years	No	Yes	Yes	No	?
67	Estella	1932	F	8	No	Section	1 month	No	No	No	No	?
68	Cato	1932	M	35	Yes	Section	?	Yes	Yes	Yes	Liver	Dead of disease
69	Pai	1932	M	62	Yes	Section	2 years	No	Yes	Yes	No	Dead of disease
70	Chesky	1932	M	53	Yes	Section	1 year	No	Yes	No	No	Dead of disease
71	Grandelaude, et al	1933	F	36	No	Section	6 months	Yes	No	Yes	No	Dead of disease
72	Montgomery & Wolman	1933	F	3	Yes	Section	2 years	No	No	Yes	Lungs	Dead of disease
73	Montgomery & Wolman	1933	F	3 mos	No	Section	2 months	No	No	Yes	No	Dead of disease
74	Montgomery & Wolman	1933	F	2	No	Section	1 month	Yes	Yes	?	No	?
75	Donati & Manginelli	1933	M	53	No	Section	?	No	Yes	?	?	?
76	Penkert	1933	F	28	No	Section	2 years	No	Yes	?	No	?
77	Penkert	1933	F	34	No	Section	5 years	No	Yes	?	No	?
78	Cordovil	1934	M	55	Yes	Section	?	Yes	Yes	Yes	No	?

CHORDOMA

TABLE I—(Cont'd) Sacro-coccygeal Chordomas Cases Collected from the Literature

No	Author	Year	Sex	Age	History of Trauma	Histol Diagn Section-Aspiration	Duration of Symptoms		Treatment		Metastasis	Survival Period	End Result
							Symptoms		Radiation	Surgery	Reurrences		
79	Fletcher et al	1935	M	33	No	Section	2 years		Yes	Yes	Yes	9 years	Dead of disease
80	Fletcher et al	1935	M	68	No	Section	8 months		No	Yes	Yes	1 year	Dead of disease
81	Fletcher et al	1935	F	43	No	Section	2 years		Yes	No	Yes	3 months	Dead of disease
82	Fletcher et al	1935	F	25	Yes	Section	2 years		No	Yes	Yes	4 years	Dead of disease
83	Fletcher et al	1935	M	47	No	Section	6 months		Yes	Yes	Yes		Dead of disease
84	Fletcher et al	1935	F	65	Yes	Section	1 year		No	Yes	Yes	3 years	Dead of disease
85	Fletcher et al	1935	M	47	No	Section	6 months		Yes	Yes	Yes	3 years	Dead of disease
86	Fletcher et al	1935	M	58	No	Section	8 months		Yes	Yes	Yes	4 years	Dead of disease
87	Fletcher et al	1935	M	61	No	Section	1 year		Yes	No	No	9 years	?
88	Fletcher et al	1935	M	25	No	Section	6 months		Yes	Yes	No	?	?
89	Pupo, et al	1935	M	49	No	Section	1 year		No	Yes	No	?	?
90	Coulthard & Harris	1935	M	53	No	Section	2 years		No	Yes	Yes	1 year	?
91	Coulthard & Harris	1935	M	33	Yes	Section	1 year		Yes	No	Yes	?	?
92	Riche et al	1935	F	52	No	Section	5 years		Yes	No	Yes	?	?
93	Mabrey	1935	F	53	Yes	Section	7 years		Yes	Yes	No	?	?
94	Mabrey	1935	M	38	Yes	Section	5 years		Yes	Yes	No	?	?
95	Mabrey	1935	M	38	Yes	Section	2 months		Yes	Yes	No	?	?
96	Mabrey	1935	F	33	No	Section	2 months		Yes	Yes	No	?	?
97	Mabrey	1935	M	47	Yes	Section	6 months		Yes	Yes	No	?	?
98	Mabrey	1935	F	43	Yes	Section	4 years		Yes	Yes	No	?	?
99	Mabrey	1935	M	35	Yes	Section	1 year		Yes	Yes	No	?	?
100	Mabrey	1935	M	42	Yes	Section	2 years		Yes	Yes	No	?	?
101	Harnos & Palmer	1936	M	71	Yes	Section	4 years		No	?	No	?	?
102	Gabriel	1936	M	49	No	Section	2 years		Yes	No	No	?	?
103	Monserat & Olascoaga	1937	M	1½	Yes	Section	2 years		Yes	No	No	?	?
104	Nash & Laskev	1937	M	54	No	Section	Yes		Yes	Yes	No	?	?
105	Cazzamalli	1937	M	45	Yes	Section	No		Yes	Yes	No	?	?

TABLE I—(Cont'd) *Sacro-coccygeal Chordomas* Cases Collected from the Literature

No	Author	Year	Sex	Age	History of Trauma	Histol Diagn Section-Aspiration	Treatment				Survival Period	End Result	
							Duration of Symptoms	Radiation	Surgery	Recurrences			
106	Barnes & Owen	1937	M	59	No	Section	1 year	Yes	No	Yes	No	1 year 6 months	Dead of disease
107	Bruce & Mekie	1937	F	44	Yes	Section	1 year	No	No		No	?	?
108	Bruce & Mekie	1937	F	62	No	Section	1 year 6 months	Yes	Yes	Yes	No	?	?
109	Odasso	1937	M	61	Yes	Section	1 year 6 months	No	Yes	Yes	No	?	?
110	Bobbio	1938	M	54	No	Section	10 years	No	Yes	Yes	No	4 years	?
111	Ghaeeb	1938	M	45	No	Section	2 years	Yes	Yes	Yes	No	2 years	Dead of disease
112	Ghaeeb	1938	M	55	No	Section	?	No	Yes	?	No	?	?
113	Lyll	1939	F	42	No	Section	10 months	No	Yes	?	No	?	?
114	Ashour	1939	M	50	Yes	Section	3 years	No	Yes	?	No	?	?
115	Bowers	1940	M	61	No	Section	1 year	No	Yes	?	No	?	?
116	Mignone	1940	M	68	No	Section	?	?	?	?	Lymph nodes Heart lungs	?	?
117	Mignone	1940	M	48	No	Section	?	?	?	?	No	?	?
118	Kilby	1941	M	60	No	Section	3 years	Yes	No	Yes	No	2 years	?
119	Harvey & Dawson	1941	M	63	Yes	Section	3 years	No	Yes	Yes	No	7 years	Living with disease
120	Harvey & Dawson	1941	F	41	No	Section	2 years	No	Yes	No	No	3 years	?
121	Harvey & Dawson	1941	M	67	No	Section	?	Yes	No	Yes	No	6 months	?
122	Harvey & Dawson	1941	F	29	No	Section	4 years	Yes	Yes	Yes	No	3 years	?
123	Olsman & Lev	1943	M	73	Yes	Section	2 years	No	Yes	Yes	No	3 years 6 months	Dead of disease
124	Rehman et al	1943	F	25	Yes	Section	3 years	Yes	Yes	?	No	?	?
125	Laust et al	1944	M	23	No	Section	8 months	Yes	No	Yes	Lungs adrenal muscle	1 year	Dead of disease
126	Kenne	1944	M	70	No	Section	4 years	Yes	Yes	Yes	No	1 year	Living with disease
127	Costa & Filho	1944	F	53	No	Section	20 years	No	Yes	Yes	No	?	?
128	Graf	1944	M	58	No	Section	?	Yes	No	Yes	Lymph nodes liver lungs skin	1 years	Dead of disease

embryonal development a thickening of the entoderm occurs in a mid-sagittal plane known as the choirdal plate and it has been shown that this plate becomes pinched off from the entoderm forming a longitudinal structure ventral to the neural canal—the primitive notochord (Fig 1) The notochord then becomes surrounded by mesenchyme and these mesenchymal cells arrange themselves in segments, thus constituting the anlage of the vertebrae Each of these

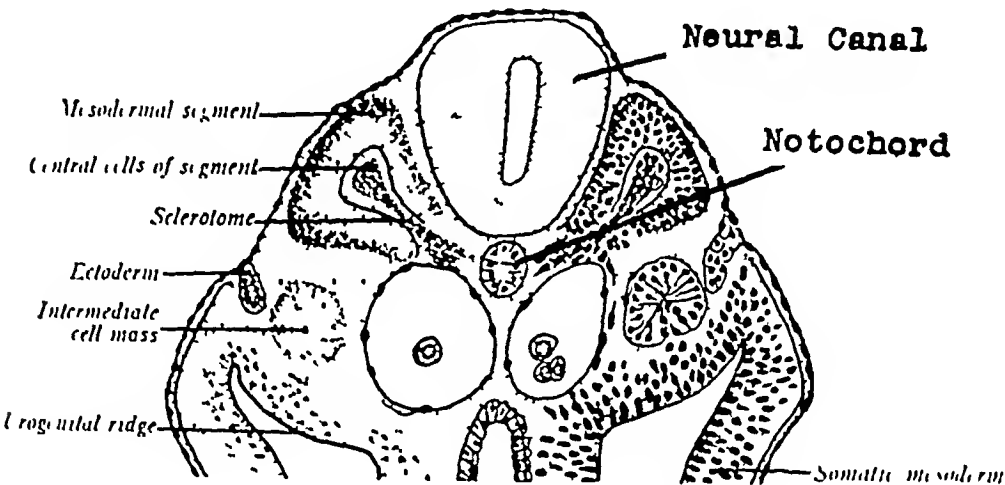


FIG 1—Transverse section of human embryo (Kollman)

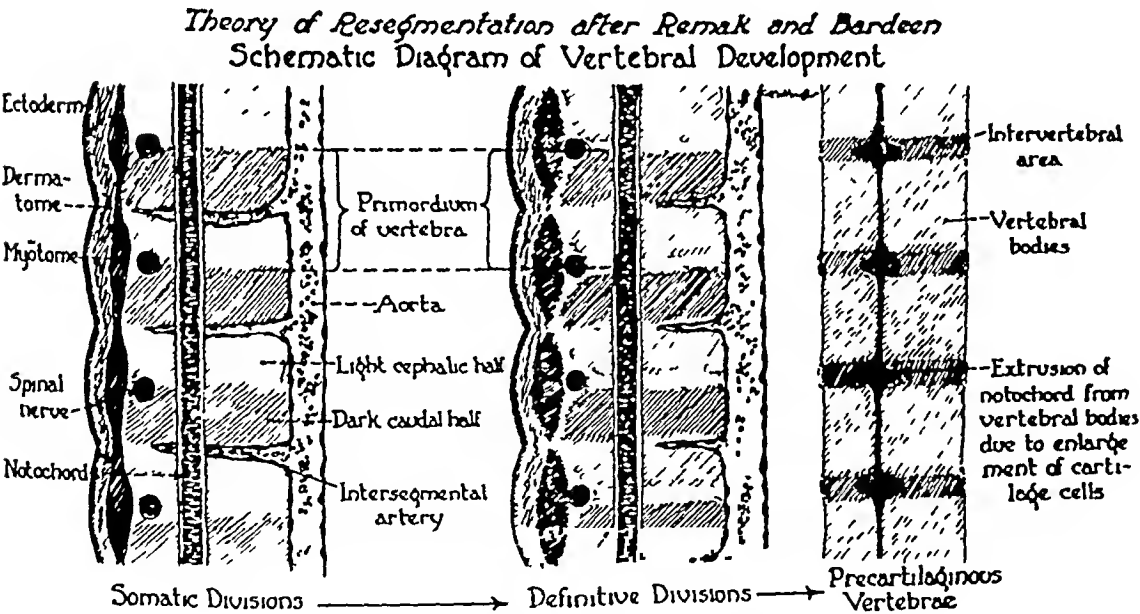


FIG 2—From Keyes and Compere

sclerotomal segments surrounding the notochord is vascularized by an intersegmental artery Between the segments there is an avascular area which remains undifferentiated for some time and this avascular zone represents the anlage of the intervertebral disc (Fig 2)

In the embryo of ten weeks the vertebral body contains typical cartilage and ossification centers and at this time the tissue between the primitive vertebrae consists of elongated fibroblastic cells As the intervertebral tissue is

compressed by the growing vertebral bodies, due to progressive cartilaginous formation and ossification, the cells on the periphery of the notochord are extruded so that the notochordal cells are only confined to the central portion of the intervertebral disc, i e , the nucleus pulposus

The bulk of available evidence indicates that chordomas arise from the primitive fibroblastic cells of the notochord. Although the present study is confined to an analysis of chordoma in the sacrococcygeal region, distribution of the tumor elsewhere along the vertebral column is of interest in this study, especially from the point of view of comparative anatomic incidence. Of the 161 reported cases of chordoma of all types encountered in the literature up to 1935 and including the Memorial Hospital series, 60 per cent were of the

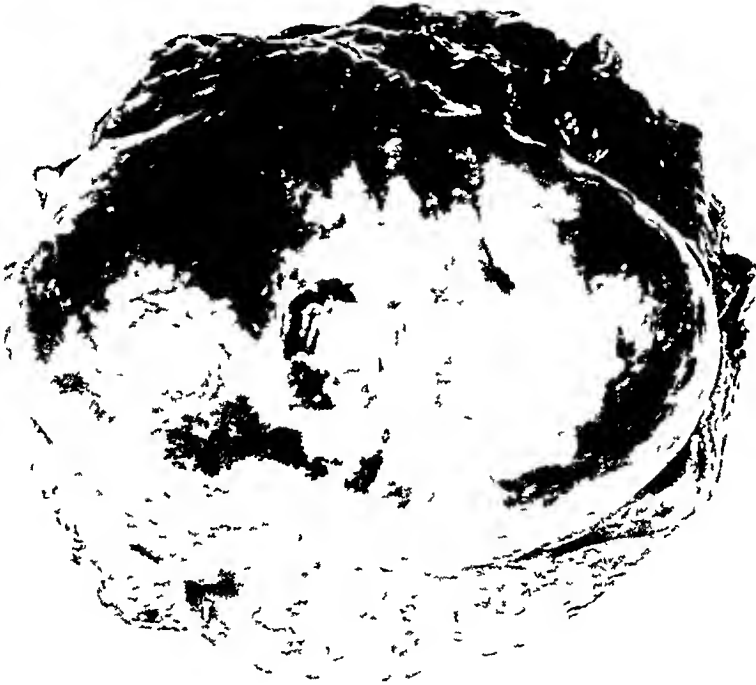


FIG 3—J M (Case 5) Surgical specimen of a lobulated and well encapsulated notochordal tumor

sacroccocygeal type and about 30 per cent occurred in the speno-occipital synchondrosis. The remaining 10 per cent were evenly distributed in the cervical, lumbar and thoracic regions. The predilection of chordoma for the sacroccocygeal area has never been satisfactorily explained, although some authors attribute this regional selectivity to the high incidence of trauma to the lower end of the spine. We have already mentioned the difficulty of evaluating the relationship of trauma to this tumor, or indeed to neoplasms in general.

PATHOLOGY

Gross Pathology A chordoma is almost always not a resectable tumor even when only moderately advanced, hence few specimens are available for

CHORDOMA

gross morphologic study In those instances where a reasonably wide surgical excision was performed (Fig 3), the tumors were found to be bulky and encapsulated The growth is characteristically lobulated and cystic in places, although true cyst formation does not occur The surface of the tumor is purplish-red in color due to its excessive vascularity On cut section, the neoplasm is seen to be composed of homogenous and translucent tissue in addition to irregular cavities filled with copious amounts of thin mucin

Histology The microscopic appearance of chordoma is characteristic in the average case and consists of large cells resembling bladder epithelium



FIG 4—R G J (Case 3) Aspiration biopsy (low magnification) showing the three main microscopic features, *i e*, presence of intra- and extra-cellular mucin, physaliphorus cells and lobular arrangement of the tumor cells

(physaliphorus cells) which contain intracellular and extracellular mucin (a primitive function of notochordal tissue) These cells are arranged in lobules or cords, or they may present a solid epithelial pattern In some instances the demarcation of the individual cells is lost and the microscopic appearance is that of a highly vacuolated syncytium The presence of mucin and vacuolization together with the specific cells found in these tumors are the most important histologic features of chordoma (Figures 4 and 5) In the more malignant types, mitotic figures, cellular pleomorphism, hyperchromatic nuclei, and multi-nucleated giant cells are seen Intracellular glycogen has been demonstrated in chordoma by some observers and this substance is probably responsible for the cytoplasmic vacuolization, nuclear vacuolization, however, is seldom seen

Although this tumor is well differentiated and of relatively low grade malignancy, less differentiated and more highly malignant types are occasionally encountered, probably accounting for the widespread metastases which occur in about 10 per cent of the cases

SYMPTOMS, MORBID ANATOMY, AND CLINICAL COURSE

A chordoma is a slow-growing tumor and does not produce clinical manifestations until it is moderately well advanced. Our review of 128 cases of sacrococcygeal chordoma reported in the literature reveals that the average duration of symptoms was 20 months before the patient finally sought relief, and in two instances 20 years elapsed from the time of onset of symptoms until the patient consulted a physician (Costa and Filho²³, and Reynes⁷⁷)

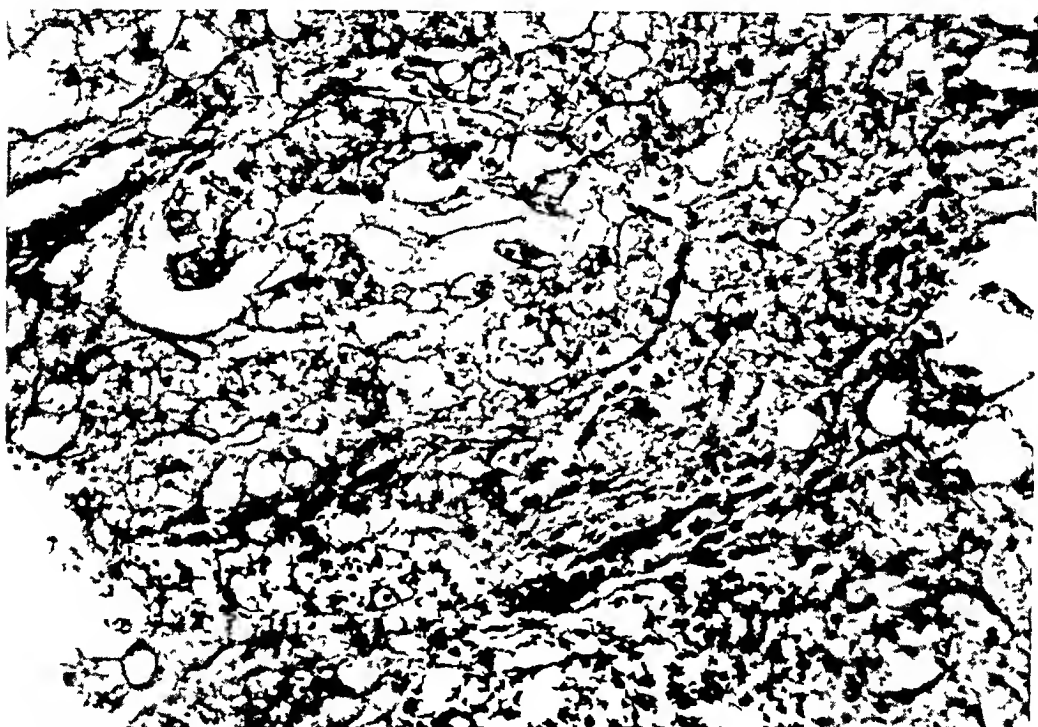


FIG 5—P K (Case 4) Aspiration biopsy (high power)—physaliphorus cells and intra- and extra-cellular mucin are seen

Symptoms are directly dependent on the location of the growth and are due to expansion of a bulky neoplasm and to destruction of bone

In sacrococcygeal chordomas pain is the earliest and most frequent symptom. It is generally mild and intermittent at first, becoming severe and intractable when the tumor involves the nerve roots and sacrum. In one-half of the cases, pain is present for many months before a tumor mass is noted. The patient's first complaint is usually pain in the rectal and anal regions, which frequently prompts the examining physician to make a diagnosis of hemorrhoids. Subsequent hemorrhoidectomy, of course, affords no relief. As the tumor begins to invade the rectum and urinary bladder, obstinate consti-

pation and urinary difficulties occur, and fecal and urinary incontinence complicate the clinical picture in most of the advanced cases. With involvement of the posterior nerve roots, motor and sensory disturbances of the lower extremities, gluteal region and external genitalia occur as well as trophic ulcers of the foot. In most of the cases the clinical course is slow but progressive, with eventual involvement of adjacent structures, particularly the sacrum. Destruction of the sacrum is an almost constant clinical manifestation of chordoma and is responsible for most of the morbidity produced during the early and moderately advanced stages of this disease. It was present in all of our cases and in one patient was complete (Case 2).

In the far-advanced cases, with widespread bone destruction involving the posterior nerve roots and pelvic viscera, the patient will present a picture of intractable pain, paraplegia and fecal and urinary incontinence. Intestinal obstruction and rectal and bladder hemorrhage may occur in the final stages of the disease.

On the other hand there have been a few reported cases in which the course of the disease was fulminating. In 1933 Montgomery and Wolman⁶³ reported two cases of sacrococcygeal chordoma in which the duration of symptoms was only one month, followed by death from widespread metastases shortly thereafter. In one of our patients (Case 7) symptoms were present for only three months, at which time a bulky, well advanced sacrococcygeal chordoma was discovered.

The most constant physical finding in sacrococcygeal chordoma is the presence of a mass, the location of which will depend upon the *direction* of growth. If it is located anteriorly and protrudes into the pelvis, pushing forward the posterior wall of the rectum, no apparent tumor will be seen on inspection and external palpation, and only by digital rectal examination can such a growth be suspected. The hollow of the sacrum should always be carefully palpated, since a sacral tumor may easily be overlooked if only the anterior wall of the rectum is examined. Obviously if the direction of the growth is posterior, a visible and palpable external tumor is present (Fig 6). Occasionally growth will extend in both directions (anteriorly and posteriorly) with production of both a pelvic and a postsacral mass. In the present series, anterior growth was present in three cases, posterior growth in two cases, and anterior and posterior growth in two cases, these proportions are in accord-



FIG 6—S M (Case 6) Clinical photo showing the tumor protruding in the lumbosacral region

ance with observations of Stewart⁸⁷ and others. If the direction of growth is anterior, a pelvic mass will ultimately be present and in the late stages of this anatomic type of the disease, an intra-abdominal tumor will be noted. Regardless of the pattern of growth, palpation of the tumor will usually reveal it to be of firm consistency, though occasionally cystic areas are also present.

Curiously enough, the soft somatic tissues of the buttock and sacral region and the overlying skin are seldom involved by tumor, and cutaneous ulceration does not occur unless injudicious roentgen radiation has been given or surgical excision attempted followed by faulty wound healing. This can be ascribed to the fact that a chordoma is a slow-growing, expanding tumor and only becomes invasive and destructive when it meets with some resistance in the path of its growth as in the sacrum. The skin of the buttock is elastic and resilient so that in cases of massive, expanding tumor it can be pushed forward to a considerable degree without actually becoming involved by the disease.

Widespread metastases do occur, though rarely, particularly to the lungs and liver and the peripheral lymph nodes (Table III). Pulmonary metastasis was observed in one of our cases (Case 6) and was reported in approximately 5 per cent of the cases in the literature.

DIAGNOSIS

Since a sacrococcygeal chordoma produces a bulky mass externally or in the hollow of the sacrum, the condition should be suspected even though it might often simulate other neoplasms which occur in the sacrococcygeal area as well as non-neoplastic diseases in or about the pelvis. The tendency for chordomas to involve the pelvic viscera late in its course and the infrequency with which the overlying skin and subcutaneous tissues are involved, together with the occasional presence of cystic areas noted on physical examination are factors which should lead the examiner to suspect the possibility of a sacrococcygeal chordoma. As already emphasized, the sacrum is invaded and destroyed by a chordoma relatively early in its course so that roentgenographic studies will reveal some evidence of bone destruction in almost every case. These roentgenographic findings together with the clinical manifestations enumerated above warrant a tentative clinical diagnosis.

Differential Diagnosis. There are several conditions from which sacrococcygeal chordoma must be differentiated since they also may produce bulging, bulky tumefaction in the sacral and parasacral regions with or without bone destruction.

(1) Chondrosarcoma of the sacrum. Although this condition occurs but rarely, it may simulate a sacrococcygeal chordoma clinically because of the presence of a sacral tumor and roentgenographic evidence of bone destruction. However, chondrosarcoma of the sacrum does not usually produce a massive tumor until it is far advanced, at which time the surrounding soft tissues and skin are extensively involved and frequently there are associated pulmonary metastases. In the early stages of sacral bone sarcoma only roentgenographic studies will clearly differentiate the two conditions, and in the last analysis a

TABLE III—*Sacro-Coccygeal Chordomas* Cases which have metastasized

	Lymph nodes	Liver	Lung	Skin and Subcut Tissue	Heart	Pento- neum	Muscle	Spleen	Kidney	Thyroid	Adrenal	Bladder	Omen- tum
1 Wigner (1910)	1												
2 Pototschung (1919)	1												
3 Peters (1919)	1	1											
4 Lewis (1921)	1	1											
5 Lewis (1921)	1					1							
6 Lewis (1921)	1												
7 Stewart (1922)				1									
8 Arguad (1926)		1											
9 Conway (1929)	1	1	1	1	1	1	1	1	1	1		1	1
10 Willis (1930)		1											
11 Cato (1933)			1										
12 Montgomery & Wolman (1933)			1										
13 Mignone (1940)	1		1		1								
14 Faust, et al (1914)			1				1				1		
15 Graf (1944)	1	1	1	1									
16 Memorial Hospital (1946)			1										
	9	6	6	3	2	2	2	1	1	1	1	1	1

positive diagnosis can only be established by microscopic examination of a biopsy specimen

(2) Tuberculosis of sacrum Tuberculous infection of the sacrum is admittedly a rare occurrence but can produce bone changes together with abscess formation, resulting in a parasacral mass. When osseous tuberculosis advances to a stage where a bulky mass is produced, soft tissue infection (cold abscess) is invariably present and the clinical differential diagnosis should not be difficult. Evidence of tuberculosis elsewhere, together with positive bacteriologic findings, will aid in establishing a definite diagnosis of sacral tuberculosis.

(3) Tumors of the female pelvic organs When a sacrococcygeal chordoma expands anteriorly to push the pelvic viscera forward, a pelvic, or occasionally an abdominal, tumor will be present, thus simulating the clinical picture of a neoplasm of the female genital tract. In one such case reported by Reich and Nechton,⁷⁶ a cystic pelvic chordoma clinically resembled an ovarian cyst in every way and the patient was even subjected to a laparotomy. Again, roentgen-ray studies of the sacral bone will almost always eliminate a primary tumor of the female genital tract since the latter does not usually invade bony structures.

(4) Tumors of the spinal cord When the posterior nerve roots become involved by a chordoma, neurological manifestations appear in the lower limbs and the later course of the disease is characterized by fecal and urinary incontinence. Since these symptoms may also be produced by tumors of the spinal cord, the latter condition must be considered in the differential diagnosis. The differential diagnosis should not be difficult since neurological symptoms and signs occur early in lesions of the spinal cord, whereas bulky tumors in the sacrococcygeal region and pelvis are rarely encountered under these conditions.

(5) Tumors of the sacral soft parts Benign and malignant tumors of the soft parts about the sacrum may clinically resemble sacrococcygeal chordoma in every way, especially when they assume massive proportions (neurofibroma, neurogenic sarcoma, spindle cell sarcoma, etc.). Again, tumors of these soft parts seldom involve bone and then only late in their course, so that roentgenographic study of the sacrum is of considerable value in establishing the diagnosis. The final decision however will depend on the microscopic study of biopsy material.

(6) Sacrococcygeal teratoma This rare and unique tumor is almost always encountered in infants and children and in most cases produces an external pedunculated growth without evidence of actual involvement of the sacrum.

(7) Cancer of the rectum A colloid rectal carcinoma situated on the posterior rectal wall may often resemble sacrococcygeal chordoma which has expanded anteriorly to invade the rectal wall. In advanced cancers of this type with invasion of the pararectal tissues, the clinical differentiation may be difficult. Since this neoplasm however, shows little tendency to bone involve-

ment, roentgen-ray studies of the pelvis are of considerable aid in distinguishing between the two conditions

Roentgenographic Features Roentgen-ray examination is an invaluable diagnostic aid since a sacrococcygeal chordoma involves the sacrum relatively early in its course in almost every case. Our analysis of previously reported cases shows that a correct radiographic diagnosis was made in only about 10 per cent of the cases, and in the Memorial Hospital series of seven cases the diagnosis of sacrococcygeal chordoma was made in four. In three of our cases where the correct diagnosis was not made on roentgen-ray examination, the roentgenologist's report was osteogenic sarcoma, giant cell tumor, and bone destruction of undetermined origin, respectively. Hsieh and Hsieh⁴⁴ made extensive roentgenographic studies of chordoma and stated that there are four signs which are rather typical of this tumor—(1) expansion (Fig 7), (2) rarefaction or destruction (Figs 8 and 9), (3) trabeculation, (4) calcification. We believe that if these roentgenographic manifestations are present in a case in which a bulky sacrococcygeal tumor is present, a diagnosis of chordoma is justifiable.



FIG 7—P. K. (Case 4) Roentgenogram of the pelvis showing bone *destruction* and *expansion*, which are characteristic of this growth.

Aspiration Biopsy At the Memorial Hospital a final diagnosis is always dependent on a histologic examination of a tissue specimen wherever biopsy is possible. Aspiration biopsy has, in our experience, been a simple and effective method of establishing a microscopic diagnosis of chordoma. This method of tissue examination obviously requires the cooperation of a pathologist who is thoroughly familiar with and trained in the interpretation of aspirated tissue. Aspiration biopsy was performed in six of the seven cases in the present series and an unequivocal diagnosis of chordoma was made in four of these. An incorrect diagnosis of chondrosarcoma was made in one of the other two cases and in the last case the amount of tissue obtained by aspiration was insufficient for microscopic study. If a diagnosis cannot be established by aspiration biopsy, incisional biopsy will necessarily have to be done since no therapeutic regimen should be decided on without a definite anatomic diagnosis.

Of all previously reported cases in the literature, we could find only two where the diagnosis was made by aspiration biopsy (Micotti,⁶⁰ Richards, and

King⁷⁹) If the technic of aspirating tissue for histological examination as described by Martin and Ellis⁵⁸ is followed and a competent tumor pathologist familiar with this material is available, aspiration biopsy should reveal the correct diagnosis in a high percentage of cases of chordoma, thus sparing the patient an incisional biopsy which may be followed by infection, ulceration or fungation



FIG 8—A K (Case 1) Lateral stereoscopic view illustrating *bone destruction*, one of the characteristic roentgenographic features of sacrococcygeal chordoma

TREATMENT

It seems to be generally accepted by most authors that surgical treatment should be employed wherever possible and a survey of previously reported cases indicates that only in rare instances are sacrococcygeal chordomas even moderately radiosensitive. Since no appreciable regression of chordoma is obtained with radiation therapy and since complete extirpation of the tumor is not possible even when radical surgery is employed, the management of this neoplasm is chiefly a matter of palliation and partial control. It is theoretically possible, however, surgically to excise a small and early chordoma, but

this disease has seldom, if ever, been observed in its incipency. The usual sequence of events in the treatment of sacrococcygeal chordoma is repeated surgical excisions with or without radiation therapy followed by repeated local recurrences (6 to 18 months) over a period of years. Machulko and Rochlin⁵⁷ described a case of sacrococcygeal chordoma where the patient survived for 16 years during which period he was subjected to four surgical procedures combined with radiation therapy.

Although radiation therapy is of little value in most cases, it is reputed to be somewhat more effective in the treatment of chordoma in children. Montgomery and Wolman⁶¹ cited three cases in children and in one of these satisfactory regression was supposed to have followed a course of roentgen radiation. Our experience with radiation therapy in the treatment of sacrococcygeal chordoma is that this mode of therapy does not induce regression but is of some value in pain control, especially during the late stages of the disease. Repeated courses of roentgen radiation are not without danger, especially in this avascular area which is always subject to pressure and necrosis. Preoperative radiation therapy is contraindicated because surgery thereafter is likely to be complicated by failure of wound healing due to interference with the blood supply of the overlying soft tissue.

These cases nearly always reach a period when control of constant pain is the major problem and one difficult to meet. A spinothalamic chordotomy was employed in two of our cases with satisfactory results (Cases 4 and 5) insofar as pain relief was concerned. More frequent use of this procedure before it becomes necessary to administer opiates will be found to alleviate materially the unhappy lot of these patients. Chordotomy for chordoma should, of course, always be bilateral.

Until an operative technic is developed which envisages complete removal of the tumor-bearing segment of the sacrum and coccyx, the present unsatisfactory results of surgery will probably not be materially improved. Such radical surgery naturally involves difficulty with regard to bladder and rectal control. It has occurred to us that these complications might be overcome by preliminary permanent colostomy and uretero-enterostomy, yet to propose such major and objectionable procedures in the early stages of this disease



FIG 9—J. M. (Case 5) Roentgenogram of pelvis showing bone destruction of the lower half of the right side of the sacrum.

(when limited extirpation might be successful) may well be considered unduly radical by the surgeon and unacceptable to the patient. These limitations only serve to emphasize the extent of the difficulties presented by this disease.

It is nevertheless our opinion that surgical excision should be attempted whenever a recurrence occurs even though there is little likelihood of complete removal. Those cases cited in the literature in which there were long term survivals were essentially treated by repeated surgical excisions.

PROGNOSIS

Recurrence following surgical excision generally occurs from six months to within a few years, as already stated. Since sacral chordomas are characteristically slow-growing, numerous recurrences will occur over a period of many years following repeated excisions with massive invasion of the pelvis in the late stages of the disease. Occasionally, however, a single surgical excision will result in satisfactory control of the disease. Fletcher, *et al*³² reported a case of sacrococcygeal chordoma which had survived for seven years following operation without recurrence or metastasis. One of Seneque and Grinda's⁸³ patients survived seven years with no evidence of recurrence. Of 128 cases reported in the literature, regional and peripheral lymph node and other metastases occurred in only 15 patients (11 per cent) as shown in Table III. In more than 50 per cent of the metastatic cases, the most frequent sites of metastasis were the regional and peripheral lymph nodes, lungs, liver, and skin, respectively. The peritoneum, heart, and striated muscles were the sites of disseminated disease in two instances. Metastasis from sacrococcygeal chordoma has also been observed in the spleen, kidney, thyroid and adrenal glands, urinary bladder and omentum. In striking contrast to the sacrococcygeal chordoma, the spheno-occipital type almost never metastasizes and there has been only one such instance cited in the literature. Pulmonary metastases were demonstrated roentgenographically in one patient (Case 6) in the series herein reported.

END RESULTS

One of our patients (Case 5) has been treated by surgery alone and was free of disease for three years, after which he developed local recurrence. This patient had subsequently been submitted to a partial removal of the recurrent disease combined with a bilateral chordotomy and at the present is living comfortably four years after his first admission. In two other cases (Case 1 and 7) surgery was combined with roentgen therapy, one of the patients expired 16 months later of leukemia at which time there was no clinical evidence of either recurrent or metastatic disease. The other patient (Case 1) has lived, with recurrent disease, for five years. Radiation therapy alone was administered in four of our cases because the neoplastic process was either too far advanced or the patient's general condition was unsuitable for surgical treatment. Of these patients only two (Cases 3 and 4) are alive at present (five and four years, respectively) with recurrent disease. The other two patients

(Cases 2 and 6) have died of advanced recurrent disease within approximately a year from the date of admission

These clinical experiences indicate that a cure cannot be obtained in cases of sacrococcygeal chordoma since the neoplasm does not lend itself to complete surgical extirpation and the most that can be hoped for with our present methods is palliation

CONCLUSIONS

From a survey of the published records of 128 cases of sacrococcygeal chordoma and of seven hitherto unpublished cases from the Memorial Hospital the following conclusions are drawn.

- 1 The condition fortunately is rare
- 2 It occurs more frequently in males and appears chiefly in the age groups of from 40 to 60
- 3 Aspiration biopsy is a useful and reliable method of establishing the diagnosis histologically
- 4 Though generally considered to be benign by many authors, sacral chordoma metastasizes in approximately 10 per cent of cases and causes the death of the patient either directly or indirectly in nearly all instances
- 5 It is of long duration, slow growing, yields but little to intensive roentgen therapy and is not amenable to complete surgical removal owing to its inaccessibility and extensive involvement of the pelvic organs and spinal cord. Local recurrence following surgical excision is a constant feature.
- 6 Pain is the most serious symptom, especially when the disease is advanced, and is difficult to control. Chordotomy seems to offer the best measure of relief and should be employed more frequently
- 7 Satisfactory methods of treatment have not as yet been developed. A method allowing more radical surgical extirpation is needed. A radical surgical program adequate to encompass sacrococcygeal chordoma in the average case would involve immediate loss of bladder and rectal control. Preliminary colostomy and uretero-enterostomy are drastic measures which the surgeon is loathe to apply for a slow-growing and relatively low-grade malignant tumor
- 8 The difficulties in the management of sacrococcygeal chordoma have been presented

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PLASMA SILK SUTURE¹ OF NERVES

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SURGEONS CLOSELY CONCERNED with the repair of injured nerves constantly strive to improve the technic of suture. No matter how many sutures have been done, the operator always feels that his last one could have been just a little better. Accuracy of alignment, adjustment of tension, control of rotation, atraumatic technic are criteria of good peripheral nerve surgery and constant challenges to the attainment of perfection. Of the technical suggestions for improvement which have appeared, that which comes closest to the ideal is some type of adhesive or glue neurorrhaphy.

DEVELOPMENT OF THE GLUE TECHNIC

There have been many attempts to introduce such a method dating back to Lotheissen in 1901 who used gelatin as the adhesive. Seddon and Associates made a most promising contribution during World War II in introducing the use of cockrel plasma fortified by tissue extract. This technic was not generally recommended because of undesirable foreign body reaction initiated by heterogeneous plasma and because of technical difficulties in application. It was further felt that the method of glue suture had no place where significant tension was present at the suture line. The introduction by Tarlov and Associates of autogenous plasma as an adhesive using a removable rubber mould placed the method on a more practical basis. The use of adhesive alone was still not feasible under even moderate tension. Spurling then suggested the use of tantalum sutures to support the clot. Experimental investigation of the method at this center resulted in our modifying the method of plasma preparation and replacing tantalum with silk. This plasma silk method has now been used in some 350 human nerve sutures. The views and conclusions in the ensuing discussion are based on the experimental and clinical application of the method.

DESCRIPTION OF PLASMA SILK METHOD

(1) *Preparation of Plasma* Plasma suitable as an adhesive may be easily obtained from whole blood. The method suggested by Tarlov was investigated experimentally before application to human cases. An adequate yield of plasma is produced by centrifuging blood in sterile paraffin-lined iced test tubes without using an anticoagulant. Examination of early experimental sutures using plasma prepared by this method showed a foreign body reaction about fine granule-like areas in the plasma. The particles initiating this reaction were identified as flecks of paraffin, separated in the centrifuging process and which

NERVE SUTURE

TABLE I—*Silk Sutures*

Nerve	No	Motor Recovery	Sensory Recovery	Motor and Sensory Recovery	Some or Partial Recovery
Ulnar	11	4	7	4	7=64%
Radial	7	4	5	4	5=71%
Median	5	1	2	1	3=60%
Sciatic	10	7	2	2	7=70%
Peroneal	9	3	3	3	3=33½%
Total	42	19	19	14	25
Percentage		43%	43%	33%	59%

TABLE II—*Plasma Silk Sutures*

Nerve	No	Motor Recovery	Sensory Recovery	Motor and Sensory Recovery	Some or Partial Recovery
		Upper Group	Lower Group		
Ulnar	52	22 of 24	21 of 52	38	21=49% 59=96%
Radial	31	23 of 25	28 of 31	29	29=93% 29=93%
Median	24	10 of 12	14 of 24	20	14=58% 22=91%
Sciatic	19	13 of 19	6 of 19	8	8=44% 14=77%
Peroneal	15	10		12	10=67% 12=75%
Total	141	113	107	82	127
Percentage		80%	76%	62%	86%

become suspended in the plasma fraction. When the paraffin was removed from the technic, this reaction disappeared. In practice, 30 cc's of blood are withdrawn from the patient into a sterile test tube after operation is started. This is centrifuged in ice-lined containers for three minutes at 2500 revolutions per minute. Some adjustment of time and speed of the centrifuge may be necessary because of variability in apparatus. When this is done, a standard yield is obtained. The plasma is kept in ice until needed and removed by a sterile pipette for application about the suture line. Proper cooling is the most important consideration in producing plasma without an anticoagulant, if attention is paid to this detail, the plasma will remain fluid and usable for 2-3 hours. Beyond this time, the tensile strength of the clot is diminished although the plasma may still be fluid.

(2) *Approximation of Nerve Ends* Efforts have been made to completely avoid using any suture material but this has not been practical. Experimentally, sciatic nerves of dogs were united under moderate tension using a pull out suture after the fashion of Bunnell for tendon sutures which was removed

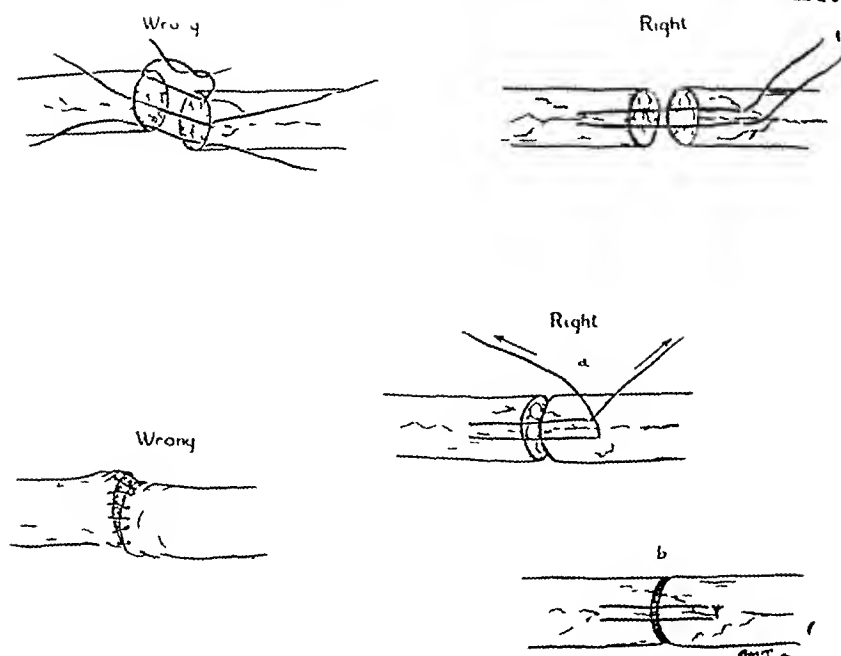


FIG 1—Insertion of the parallel stay sutures

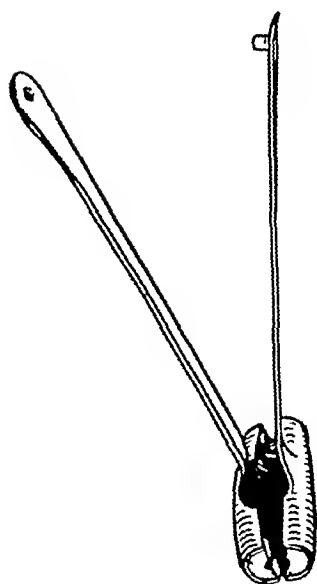


FIG 2 — The spoon mould. Note the sponge rubber cuff at the ends

after an autogenous clot was applied. Examination at the end of 48 hours showed the nerve ends to be completely separated. If an adhesive is to be used, it should be regarded rather as a supporting mechanism with tension largely controlled by a small number of sutures. In practice, it has been possible to reduce the number of sutures necessary to two of the perineural stay type when a clot is used in addition.

The sutures are inserted about $\frac{1}{4}$ inch from the prepared nerve ends and dip into the perineurium but not into subjacent fasciculi. They are applied one on each side of the trunk in parallel fashion (Fig 1). The knots are tightened gradually so that the desired approximation and adjustment is obtained. This enables minute correction of the apposed surfaces.

(3) *Application of Clot* The removable rubber mould or cup as suggested by Tarlov⁴ has simplified this step considerably. In addition to this a combined mould and spoon with a cuff as illustrated has also (Fig 2) been useful. After the stay sutures have been inserted, the cup is fixed in place and a final minute adjustment of the nerve faces is done through the opening provided. Bleeding from nerve ends must be controlled before the clot is applied. In this connection the rubber cuff serves as a hemostat as well as preventing leakage of the plasma. The cool plasma is removed in a sterile pipette or eye dropper, warmed gently by hot saline sponges and dropped into

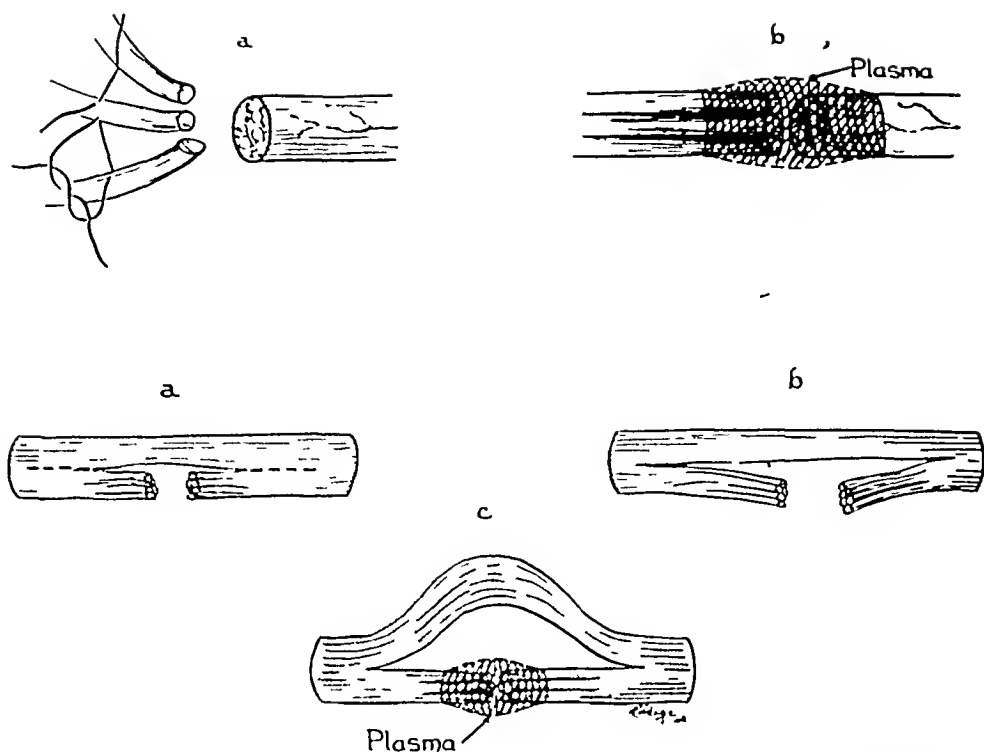


FIG 3—Application of plasma silk method to branch lesions and notch defects



FIG 4—A satisfactory clot at operation

the cup. The container is filled to the top and the plasma is allowed to clot. A satisfactory clot is obtained in 3-7 minutes, retraction (Fig 4) is encouraged by gently separating the plasma from the edges of the cup. When firm, the clot is separated and the container gently removed.

COMPARATIVE CLINICAL RESULTS FOLLOWING SILK AND PLASMA SILK METHODS

In this study, a control series of routine silk sutures has been done and is compared with a series by the plasma silk technique so that some definite conclusions may be reached. There are many difficulties in setting up comparable groups of this nature for study. A most desirable common denominator is

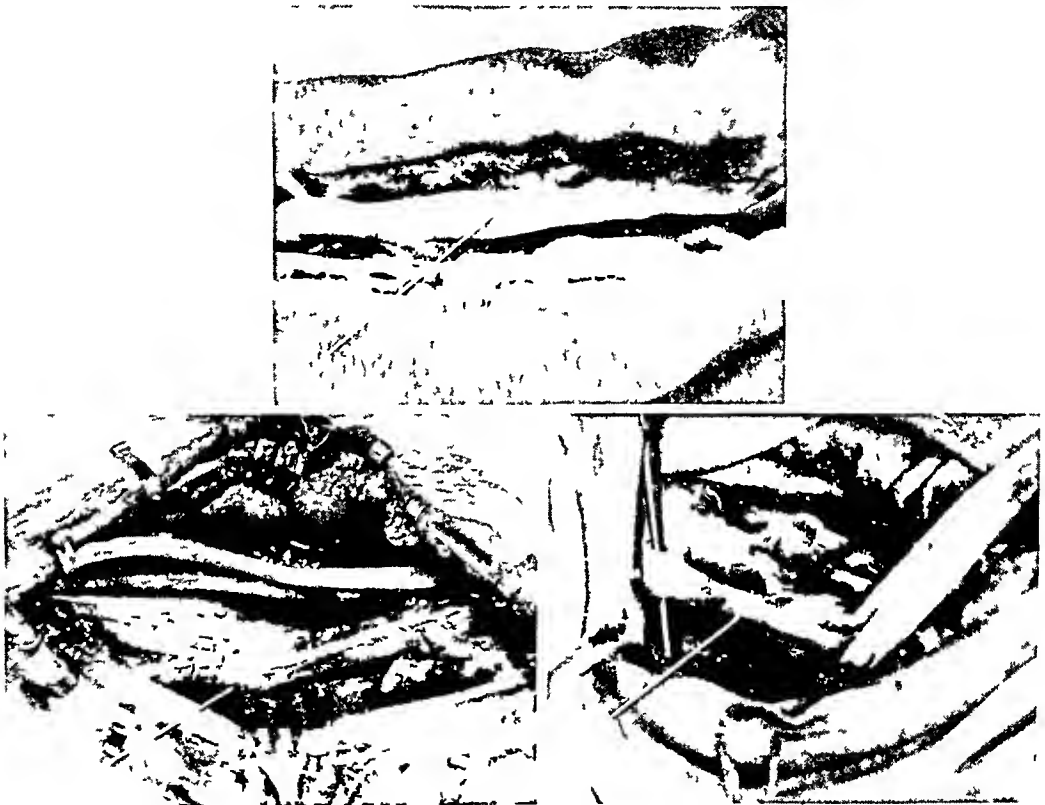


FIG 5—(A) Human plasma suture three months after operation. S.L. suture line.
(B) Human plasma suture four months after operation.
(C) Human plasma suture six months after operation.

that all the sutures be done by the same operator. This has been accomplished in this series. A completely analogous series would entail sutures at the same level, on the same nerve, in the same patient on opposite sides, which obviously is not possible. Sutures comparable as to site, length of time following injury, length of gap, severity of injury, *etc*, have been reviewed. The figures presented comprise a portion only of the total number of operations. They include those cases in which recovery in part could be reasonably expected, estimating regeneration at the rate of 1 inch per month from the level of nerve union.

The silk sutures have been assessed at a longer interval following operation than has been the case with the glue sutures. The treatment apart from the method of nerve suture has been the same in all cases. The postoperative routine included monthly changes of plaster until the extremity was straight. Electrical stimulation was initiated through plaster as soon as the operative wound was healed and was continued as far as possible until voluntary power returned. The assessment of recovery in this series has been on motor and sensory return only. When even a carefully elicited Tinel test is done, apparent progress can be demonstrated in all cases. It is felt that any evaluation of results based on Tinel's sign alone is not reliable. Electromyographic studies of progress have also been done but for the present purposes of comparison, even this evidence has not been documented as definite recovery. The return of voluntary power has been regarded as the most reliable evidence of nerve regeneration but appreciation and accurate localization of touch, pinch and pin prick in the zone of autonomous supply have also been interpreted as recovery.

RESULTS

The following tables show in summary figures comparing plain silk and plasma silk techniques.

ANALYSIS OF RESULTS

1 *Discussion of Comparative Figures* The figures presented do not constitute a large enough series to be considered statistically. Recovery, both partial and complete has been superior in all groups sutured by the plasma silk technic. The difference is significant in all nerves but is most striking in the peroneal nerve and least in the case of the sciatic.

2 *Further Discussion* (a) *Limitations* The complete plasma silk routine could not be applied in all instances. Sutures in certain inaccessible regions made application of the cup awkward. For example, in tight sutures of the radial nerve at the elbow, acute flexion of forearm makes the insertion of the container difficult and pooling of the plasma only may be done. Despite extensive exposure and mobilization, some injuries were still encountered in which severe tension was present. These gaps sometimes need central transfixion sutures and multiple rim sutures as well so that any contribution by the plasma is at a minimum. However, improved control of infection and early secondary closure of wounds has decreased the incidence of irreparable gaps, paving the way for wider use of a meticulously accurate method.

3 *Advantages of Plasma Silk Method* The explanation for the superiority of the combined technic is apparent in technical advances rather than in any magic contribution by the plasma to the process of regeneration.

(a) *Control of Nerve Ends* The placing of the cut surfaces so that they face each other squarely without distortion is a delicate and fussy maneuver. In the classical method of multiple rim stitches, each new bite may sink to a different level, altering the control and direction of the preceding stitch. The parallel stay sutures provide a pivot affording minute correction and final adjustment of the ends before being solidified by the clot.

(b) Tension Adjustment An equally difficult and frequently abandoned task is that of obtaining just the right amount of tension at the suture line. As each new suture is inserted, the fine adjustment is disturbed in tightening the knots. A further variable occurs since no two will be fixed with exactly the same tension. The usual land mark in multiple stitch insertion is the retracted epineurium. The edge may present at a different level at various points of the circumference so that it is an unreliable land mark. Unequal tension resulting from multiple sutures favours entanglement and buckling together of nerve bundles. In ends tightly apposed, compression inserts the proximal bundles between the distal tubes instead of leaving them in a relaxed facing position. As regeneration proceeds, angulation and confusion is increased, stifling smooth flow across the gap.

(c) Suture Material Selection of the most desirable suture material involves several considerations. The structure of the substance controls the foreign body tissue reaction but an equally important consideration is the amount of that substance needed for a secure union. No advantage is gained in using a fine inert thread if double the amount is needed for the suture. The consistency of the suture material has a bearing on the security of the knot which is produced. The uneven surface of silk and similar substances has a resistance or friction which favours a secure grip in tying. Material such as wire on the other hand lacks this property and the smoothness of the surface contributes to a less secure knot. Adjustment of tension with silk has a certain resistance easily gauged and controlled. Metallic or allied material may give way suddenly or partially crack as the tension is adjusted. For these reasons, fine ophthalmic silk has been more reliable in our hands than tantalum.

(d) Method of Introducing Suture Material The method of introducing suture material is an obvious controlling factor which has been frequently overlooked. If multiple sutures are necessary, each new insertion or perforation is a traumatizing episode damaging nerve bundles and initiating bleeding. This constitutes a further reason for using as few sutures as possible. Trauma to the nerve ends is controlled by the mechanism of insertion as well as by the fineness of the suture material. To obtain advantage from fine suture material, the needle carrying it should be as small as the material itself. In addition to damage produced by needle and thread, simplicity of application is also a factor. Less control is possible when tying invisible sutures. This increased handling of nerve trunks produces more damage than when a slightly larger more visible material is used. It has seemed best to replace as many sutures as possible by a properly applied autogenous glue.

(e) Protection of Suture Line Some form of insulation of the vital union tissue has long been felt to be of value. This was based on a desire to prevent infection extending into nerve ends and later causing strangling intraneural fibrosis. Advances in the control of infection no longer make this the main purpose of insulation, but some important considerations remain. Chief among these is some mechanism of immobilization at the suture line favouring the progress of axoplasm across the gap in oriented stream lines. A protec-

tive covering also minimizes extraneous stress or traction at the suture line and prevents creeping encroachment of fibrosis from adjacent structures. An autogenous plasma clot provides an immobilizing cuff which fulfills most of these desiderata. It serves as a further protection against irritation set up by silk or other foreign material necessary in the neurorrhaphy.

CONCLUSIONS

1. Plasma silk suture of peripheral nerves has proved practical in over 350 cases. The modified technic has made possible most advantages of an adhesive method.

2. Superior results have been obtained in all nerves with the most striking improvement occurring in the peroneal.

3. Improved primary treatment of wounds and early neurorrhaphy has allowed more extensive use than was originally felt possible. Some limitations in its use remain in awkward situations and in sutures under excessive tension.

4. The method outlined is simple and no complications have resulted. The moderate tension encountered in repairing nerves in gunshot wounds has been effectively controlled by few sutures supported by a clot.

5. Apart from its value in routine suture, special advantages have been found in applying the method to notch defects, branch lesions and small nerves.

6. The series may not be considered statistically significant but it demonstrates the possibilities of a trend towards sutureless re-union of nerve tissue.

7. The improved technical management afforded by the method enables precision accuracy. Following meticulous attention to the minutiae of each step in the suture process, more orderly regeneration may reasonably be expected.

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OPERATIVE EXPOSURE OF THE BLOOD VESSELS IN THE SUPERIOR ANTERIOR MEDIASTINUM*

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ADEQUATE EXPOSURE is essential in any operation in the anterior superior mediastinum if damage to important blood vessels and nerves is to be avoided. The necessity for perfectly ample exposure is particularly important when operation is performed for an aneurysm or arteriovenous fistula of the mediastinal vessels. Almost every conceivable type of operative approach has been employed since Valentine Mott first ligated the innominate artery in 1818 in an effort to cure a traumatic subclavian aneurysm.¹

In Greenough's excellent review of operations upon the innominate artery² the fact is brought out that safety can only be achieved by adequate resection of the overlying bony framework. In only 37 of the 91 cases of innominate ligation or attempted ligation was resection or osteotomy of the overlying bones performed, and it was apparent that inadequate exposure was the primary factor in a number of fatalities. An idea of the multiplicity of incisions is obtained from his study. In 11 cases a portion of a clavicle and of the manubrium was resected, while in 11 others only a part of the clavicle was excised, combined in one case with partial excision of the first costal cartilage. In the remainder, such procedures were carried out as sterno-clavicular disarticulation, mid-line splitting of the sternum, partial excision of the manubrium, clavicle and first rib, and resection of the manubrium with or without excision of the first two costal cartilages.

The type of operation in which exposure is accomplished by resection of bone is illustrated by the operation of Bardenheuer³ in which the inner part of one clavicle and first rib are removed, the manubrium is sectioned transversely about an inch below its superior border, following which the opposite clavicle, first and second ribs are divided and the freed manubrium is excised. Various modifications of this operation have been used. Similar exposure is obtained by the osteoplastic operation of Kocher,⁴ a procedure quite similar to that which had been advanced by Giordano and Auvray. The manubrium is reflected as a flap attached to the costal cartilages on one side after division or disarticulation of the clavicles, the first and second costal cartilages on one side, and transection of the sternum at the level of the second interspace. The exposure of Sauerbruch⁵ has been widely used for certain mediastinal explorations and occasionally for vascular operations. It involves splitting of the sternum longitudinally down to the level of the third interspace and cutting it across into the third interspace.

Each case must be considered as an individual problem and an effort must

* Aided by a grant from the Office of Naval Research, the United States Navy

be made to choose the ideal operative approach. The best type of incision for one is not necessarily the best for another case. Indeed the wide utility of different approaches is exemplified by the last three reported cases of innominate aneurysms and arteriovenous fistulas. Elkin⁶ resected the inner half of the clavicle, the second costal cartilage and inner portion of rib, divided the manubrium and excised a portion of the right half of it. Trent⁷ used a transpleural approach after resection of the second rib and cartilage and division of the third. Lindskog⁸ excised the proximal portion of the second costal cartilage, rongeuired partly across the sternum at this level, split the manubrium vertically with a Gigli saw introduced from above, and divided the clavicle.

Though aware of the value of various types of approach to the vessels in the superior anterior mediastinum, I have felt that it might be helpful to record my experience with one type of operative exposure which has proved exceedingly satisfactory in approaching aneurysms and fistulas involving a number of different mediastinal vessels. I shall include in this presentation brief case reports in order to demonstrate the general usefulness of this procedure. I had originally used, with slight modification, the operation of Sauerbruch in exposing an innominate aneurysm (Case 3). The sternum was split down to the level of the third interspace and across into both interspaces at this level. The exposure of the arch of the aorta, the proximal and mid portions of the innominate vessels and the main aneurysmal mass was excellent. However, in spite of wide retraction of the divided sternum, it was impossible to obtain adequate visualization of the subclavian and carotid arteries and the superior pole of the aneurysm which were hidden under the upper part of the manubrium and the sterno-clavicular joint. I have subsequently exposed several other large innominate aneurysms through the same incision. Again excellent visualization of the aneurysm and the origin of the innominate artery was obtained but the subclavian and, to a lesser extent, the carotid arteries were not satisfactorily visualized. In these cases the extreme dilatation of the innominate as it came off the aorta precluded, it was thought, ligation of the artery and treatment was confined to wiring and coagulation.

Because of this experience I have combined splitting of the sternum with resection of the inner third of the clavicle. Excision rather than transection of the clavicle has been performed because of considerations which have been presented elsewhere.^{9, 10} This procedure has proved an excellent method for obtaining good exposure. An incision is made from the mid portion of the clavicle down over the sternoclavicular joint to the midline and is continued down over the sternum to the level of the third or fourth interspace. The platysma is divided. The inner third of the clavicle is resected subperiosteally by disarticulation of the sternal end and division of the other end with a Gigli saw. The sternal part of the sternocleidomastoid is divided as well as part of the clavicular origin of this muscle. The sternohyoid and sternothyroid muscles are similarly severed near their origin. Ordinarily it is necessary to divide these muscles only on the side from which the clavicle is removed. A finger is gently passed behind the manubrium from above, and it is generally

feasible to separate the manubrium from the underlying structures in this manner. Occasionally a blunt dissector has been used cautiously in this dissection, but only with the constant guidance of the palpating finger in order to avoid trauma to the vessels beneath. The anterior periosteum of the sternum is incised in the midline and the sternum is split down to the level of the second or third interspace. The Schumacher sternal shears is ideal for this purpose, the Lebsche knife is also satisfactory though in my experience the bone tends to split in advance of the knife and not always in the midline. Once the sternum has been divided for some distance its edges can be retracted with bone hooks and one can palpate the underlying structures more satisfactorily and determine whether the sternal transection should be carried out at the

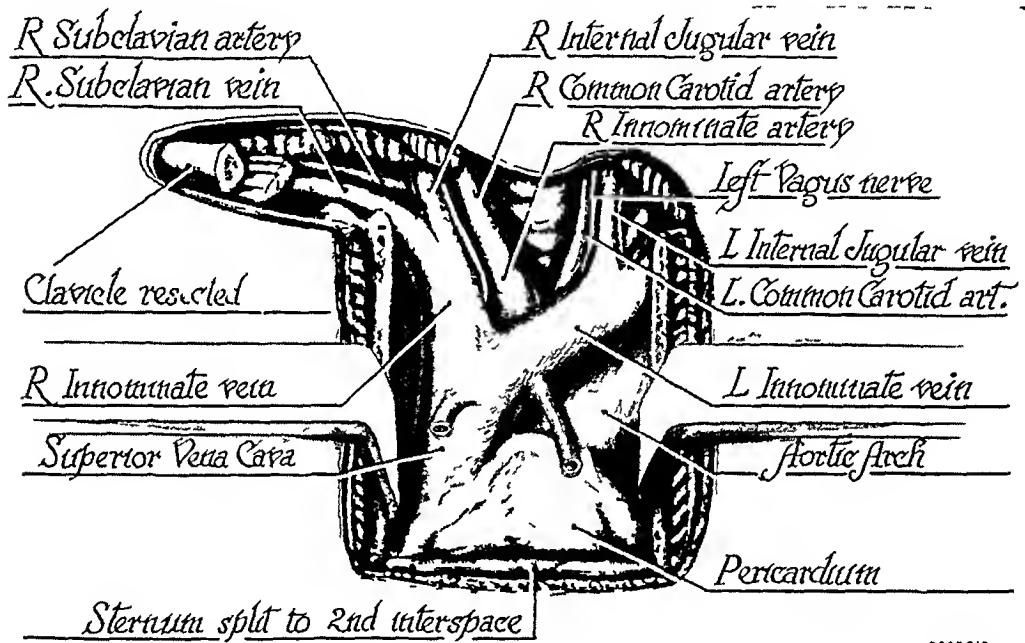


FIG 1—Illustration of the operative exposure. For the sake of simplicity the phrenic nerves, the thymus gland, the periosteum of the clavicle, the branches of the subclavian vessels and the divided right anterior scalene muscle are not shown.

second or third interspace in order to provide the desired exposure. One can also free more completely the sternum from the tissues beneath. The sternum is then divided across into both interspaces at the appropriate level after incising the periosteum across and freeing the outer borders. An ordinary rib shears can be used for this purpose. One now retracts the halves of the sternum widely, pushes the loose areolar tissue and thymus to one side or excises them, and brings into view the great vessels. A small rib spreader is substituted for the bone hooks.

The structures exposed are shown in a somewhat simplified semi-diagrammatic form in Figure 1. The innominate veins and the superior vena cava are in view. The arch of the aorta, the innominate, subclavian and carotid arteries are identified without difficulty. The phrenic nerves (which

are omitted in the drawing) and the vagi are usually readily seen. If it is required, the subclavian artery can be dissected out laterally following section of the anterior scalene muscle, care being exercised to avoid trauma to the phrenic. The first branches of the subclavian are ordinarily visible. In the drawing the sternal origin of the sternomastoid muscle on the side opposite that of the clavicular resection is shown divided, generally this is unnecessary. The drawing also shows the subclavian and carotid vessels on the side opposite that of the clavicular resection visible for a greater distance than is usually the case. In this illustration the sternum has been transected at the

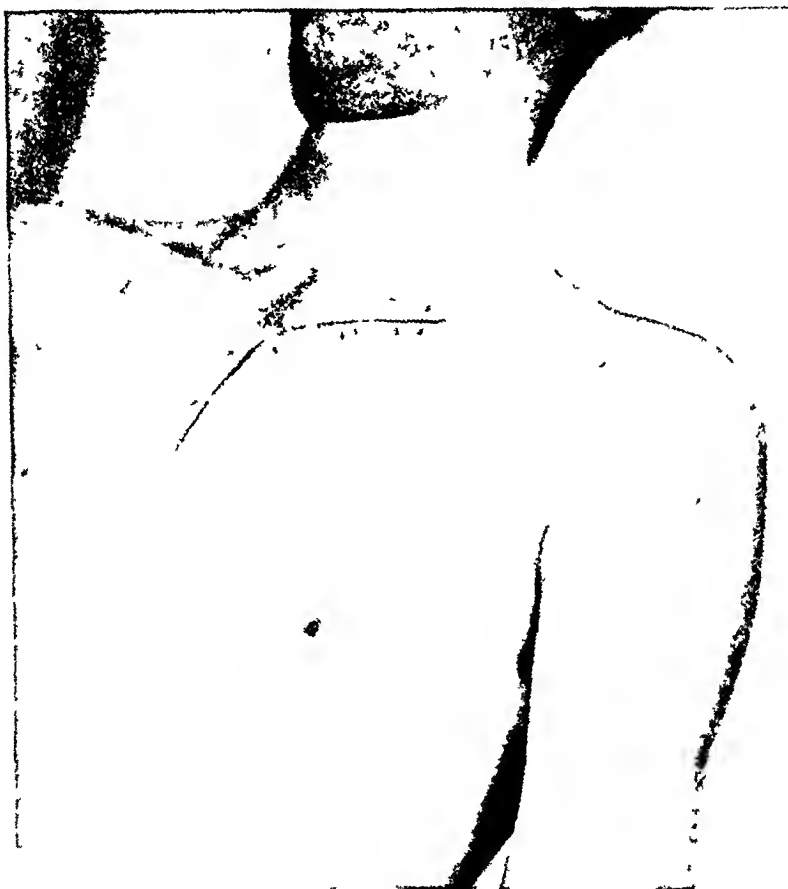


FIG 2—Wound two weeks after operation (Case 6). The contour of the chest is relatively normal.

second interspace although sometimes division must be carried out an interspace lower in order to provide the same exposure. Indeed there is wide variation in the position of the mediastinal structures in relation to the overlying bony framework. Occasionally the arch of the aorta is as high as the superior border of the manubrium. Sometimes the pericardium is barely in view. At times the superior vena cava is seen to be of considerable length as in this drawing, while in other cases the innominate veins appear to join more caudally into a short vena cava.

Once the vascular surgery is accomplished, the wound is closed in layers. The sternum is re-approximated either with wire sutures placed through drill

holes or by silk sutures in the periosteum. The clavicular periosteal bed is carefully closed with interrupted silk sutures. In some cases the excised

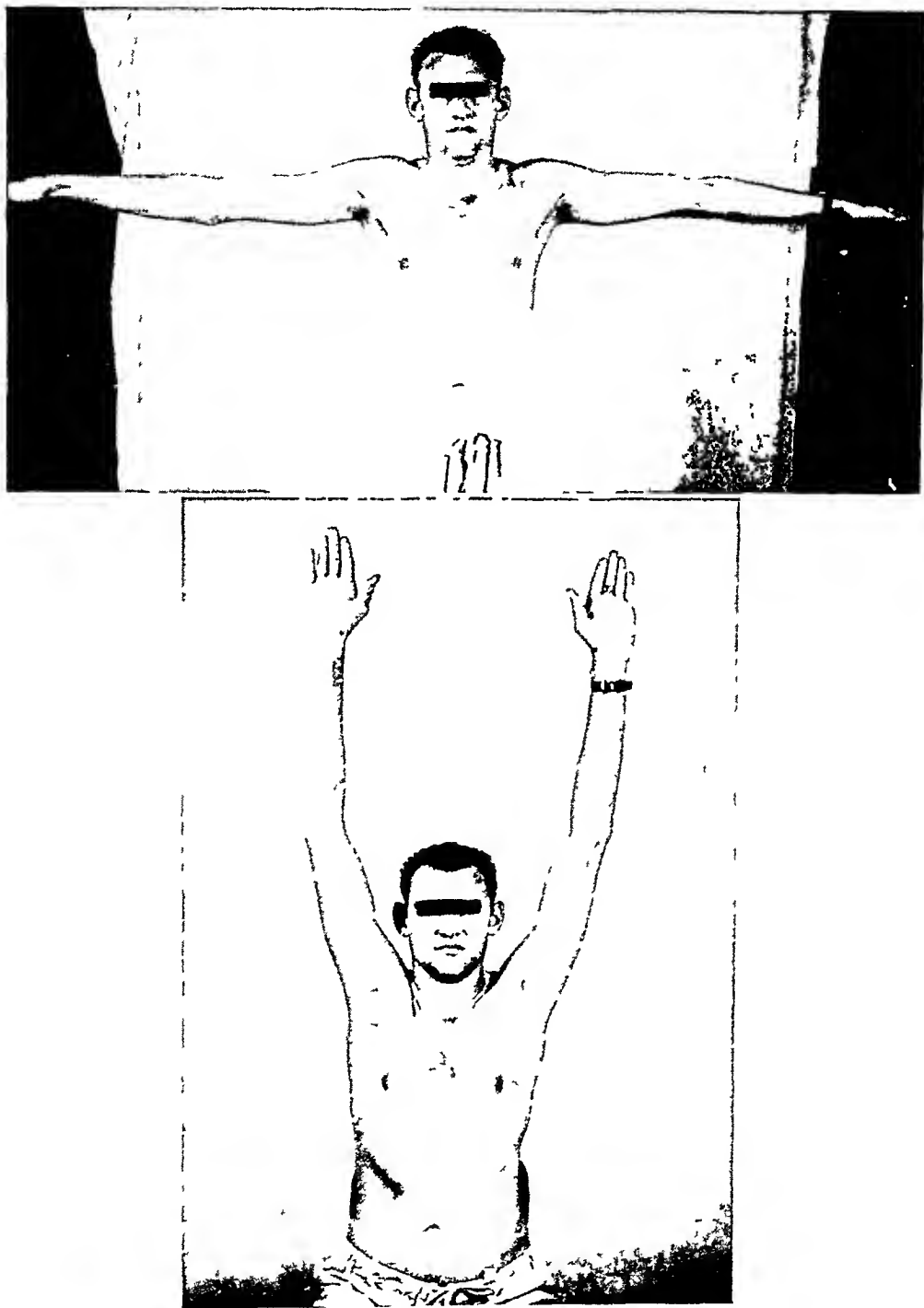


FIG 3—Photograph taken 2 months after operation showing normal range of shoulder motion (Case 4)

portion of clavicle has been replaced as bone chips, a procedure which I feel is advisable since it hastens bony repair.¹⁰ The muscles, fascia and skin are now

brought together with silk sutures. The skin incision is shown in Figure 2 and the normal range of shoulder motion after operation in Figure 3

CASE REPORTS

Case 1—The patient was a 35-year-old officer who had been wounded on August 19, 1944 by a small shell fragment which entered the right infraclavicular area near the sternum. In addition he received a shell fragment injury of the left thigh which resulted in a large avulsed wound. He was found to have signs of an arteriovenous fistula and was returned to the Zone of the Interior and admitted to the Mayo General Hospital.

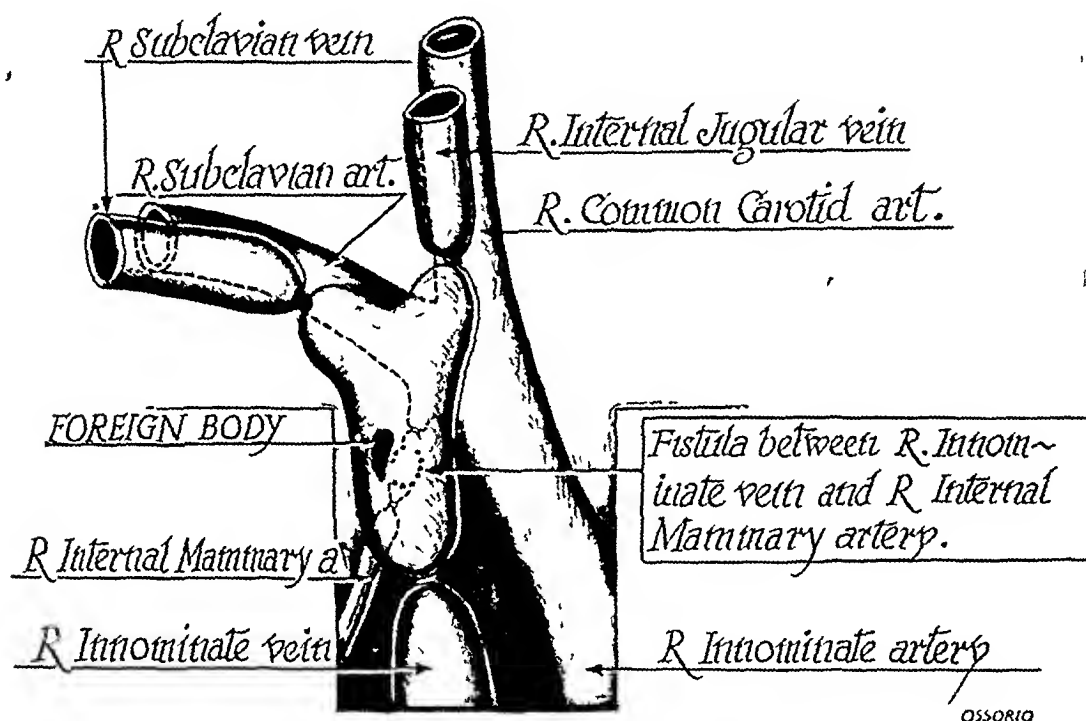


FIG 4—Condition found at operation in Case 1. Fistula between internal mammary artery and innominate vein. The point of ligation and division of the artery and vein are indicated.

He was aware of a buzzing, throbbing sensation in the right sternoclavicular area but had noted no other symptoms.

Examination revealed a continuous thrill and murmur most prominent just below the sternal end of the clavicle. The bruit was transmitted down towards the heart, out over the course of the subclavian and axillary vessels, and a little less well up into the neck. The thrill and bruit could not be obliterated by digital compression. Blood pressure was 108/58. There were no circulatory changes in the right upper extremity. Electrocardiogram was normal, roentgenograms negative except for the demonstration of a small fragment of the metal below the sternoclavicular joint.

On February 16, 1945 exploration was carried out. The condition found is shown in Figure 4. There was a fistula between the internal mammary artery and the overlying innominate vein. The shell fragment was imbedded in the posterior wall of the vein, which was indurated and scarred in this area. The fistula was excised with quadruple ligation of the vessels. Convalescence was uneventful and the patient has remained well.

Case 2—The patient was a 24-year-old soldier who had been struck by shell frag-

ments on October 20, 1944, receiving penetrating wounds of the left malar region, left side of neck, and left supraclavicular fossa. The shell blast caused temporary loss of consciousness and loss of hearing in the left ear. He became hoarse shortly after injury. He was found to have a fracture of the maxilla which was reduced through a Caldwell-Luc approach, and a massive hemothorax which was treated by thoracentesis. Hearing began to improve but a distressing tinnitus persisted. He developed a throbbing, aching pain in the left arm and subsequently a persistent left ulnar hypesthesia. The hoarseness persisted. A decortication of the left lung was performed and he was admitted to the Mayo General Hospital on March 9, 1945, with a diagnosis of left carotid aneurysm. He complained of abnormal pulsation in the left side of the neck, throbbing pain in the left arm, numbness in left ulnar area, tinnitus in the left ear, watering of the left eye, and hoarseness.

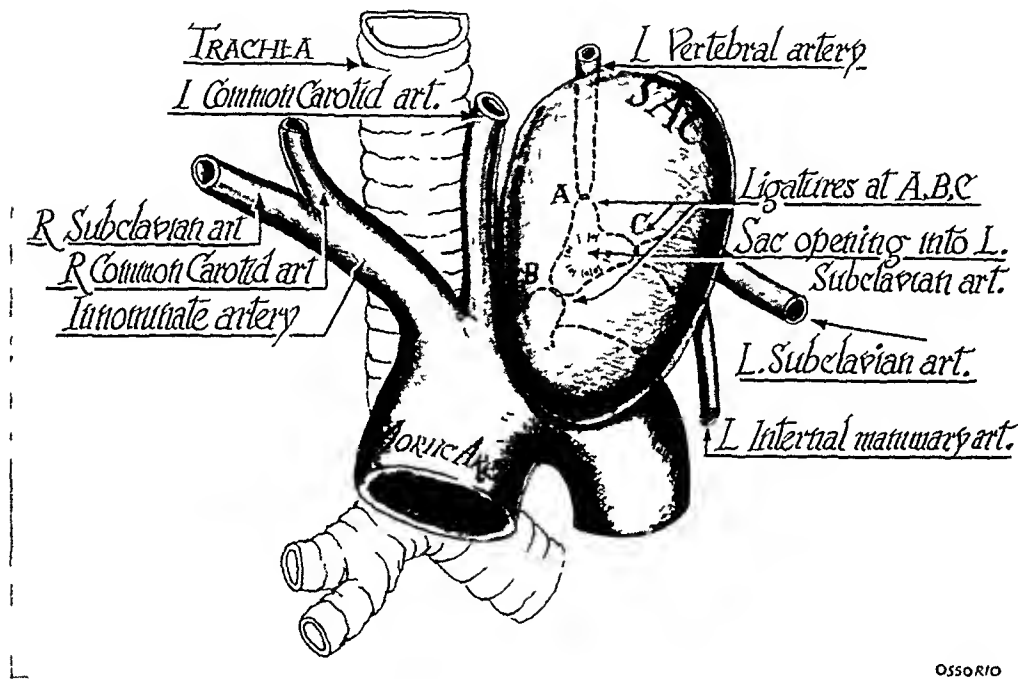


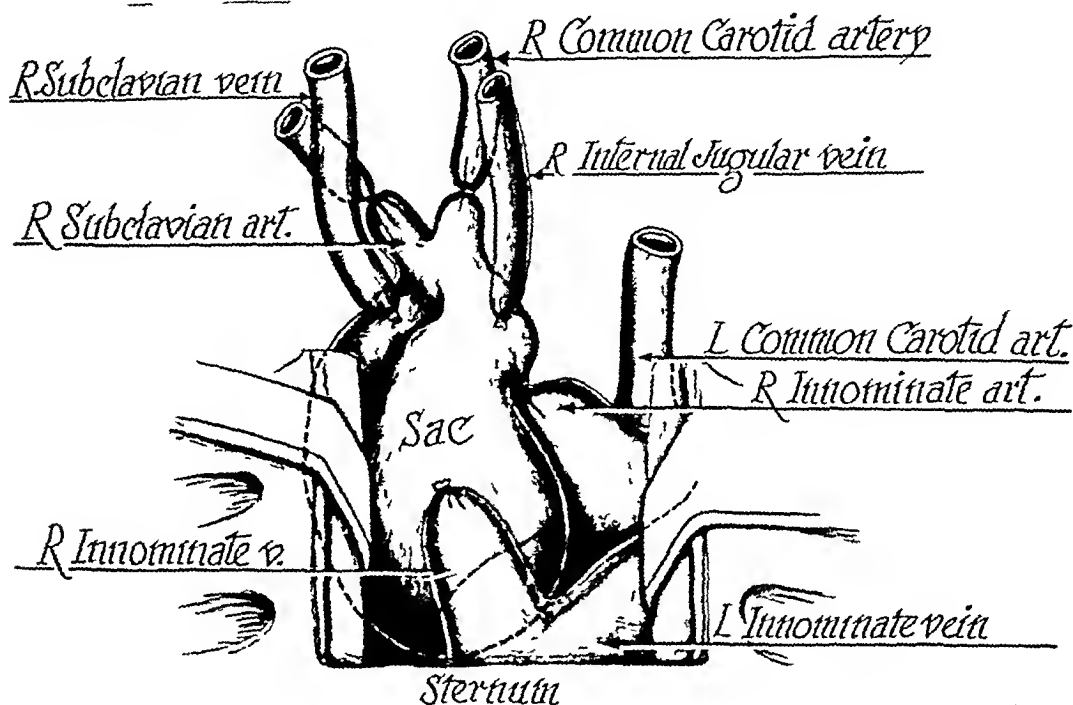
FIG 5—Condition found at operation in Case 2. Subclavian aneurysm. The points of ligation of the arteries are indicated.

Examination showed a pulsating mass at the base of the left side of the neck without thrill but with a loud systolic bruit. Digital compression caused cessation of the bruit. Pressure over the inner part of the mass interrupted carotid pulsation and reduced the radial pulse; pressure over the outer part obliterated the brachial pulse. Blood pressure was 116/70. There was no circulatory disturbance of the left upper extremity. There was left ulnar hypesthesia, left recurrent laryngeal paralysis, and bilateral nerve-type deafness. Electrocardiograms were normal and roentgenograms not informative. There was evidence of good collateral circulation during the reactive hyperemia test with the left subclavian occluded. He stood prolonged left carotid compression without symptoms.

After a furlough and repeated digital occlusion of the carotid artery the patient was operated upon on May 4, with a diagnosis of traumatic aneurysm of the subclavian or common carotid artery. The condition found is illustrated in Figure 5. The left vagus nerve was stretched out over the large aneurysm, thinned but otherwise apparently uninjured. The carotid was uninvolved. The first portion of the subclavian was isolated

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mesial to and underneath the sac and a tape placed about it. The subclavian was isolated distal to the sac. The vessel was dissected back towards the involved area beneath the aneurysm. When the artery was then occluded proximally and distally, the sac ceased to pulsate, it continued to fill rapidly, however, with bright arterial blood, as demonstrated by needle aspiration. It was now evident that the vertebral artery opened into the sac and it was feared that simple proximal and distal ligation of the subclavian would not effect a cure. Since the vertebral artery was inaccessible because of the overlying sac and adjacent scarring, the sac was carefully freed back to its mouth during temporary occlusion of the subclavian on either side, following which the sac was opened widely. Back bleeding was prevented by digital pressure while the subclavian was ligated just



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FIG 6—Condition found at operation in Case 3. Innominate aneurysm. The subclavian and carotid arteries were divided between ligatures and the sac was opened and emptied of its thrombus.

proximally and distally and the vertebral was dissected free and ligated. The sac was then resected subtotally. The overlying innominate, subclavian and internal jugular veins had been ligated and divided.

The patient withstood the procedure well but remained drowsy after operation. There was no paralysis of the extremities. About 8 hours later he complained of severe headache,—became stuporous, then comatose, and died about 22 hours after operation. Autopsy revealed extensive encephalomalacia of the left cerebellum. The circle of Willis was normal and there was no thrombosis of the left vertebral. No embolus was demonstrated.

Case 3—This case is reported in detail elsewhere¹¹. The patient was a 25-year-old soldier with a traumatic innominate aneurysm. Exploration was carried out 7 months after injury. Partial proximal ligation with a fascial band and cellophane was performed rather than complete ligation because marked ischemia of the hand was noted during temporary occlusion of the innominate artery. The reduction in oscillometry which followed was only temporary. A dorsal sympathectomy was carried out 3 weeks later and the mediastinum was explored again 3½ months after the original operation.

ligation of the innominate, subclavian, and internal jugular veins and resection of the intervening segment, the innominate artery was ligated proximally, the subclavian and carotid arteries were divided between ligatures distally, and the sac was opened and evacuated of its thrombus (Fig 6) Convalescence was uneventful and the patient has remained well, except for slight general weakness and a little fatigueability of the right hand

Case 4—The patient was a 27-year-old soldier who had received multiple injuries from shell fragments on January 28, 1945 He was wounded in the right thigh, the left buttock, the back, and the posterior aspect of his neck After a time he was evacuated to the Zone of the Interior and admitted to the Mayo General Hospital with a diagnosis of right subclavian arteriovenous fistula On admission he complained of a buzzing sen-

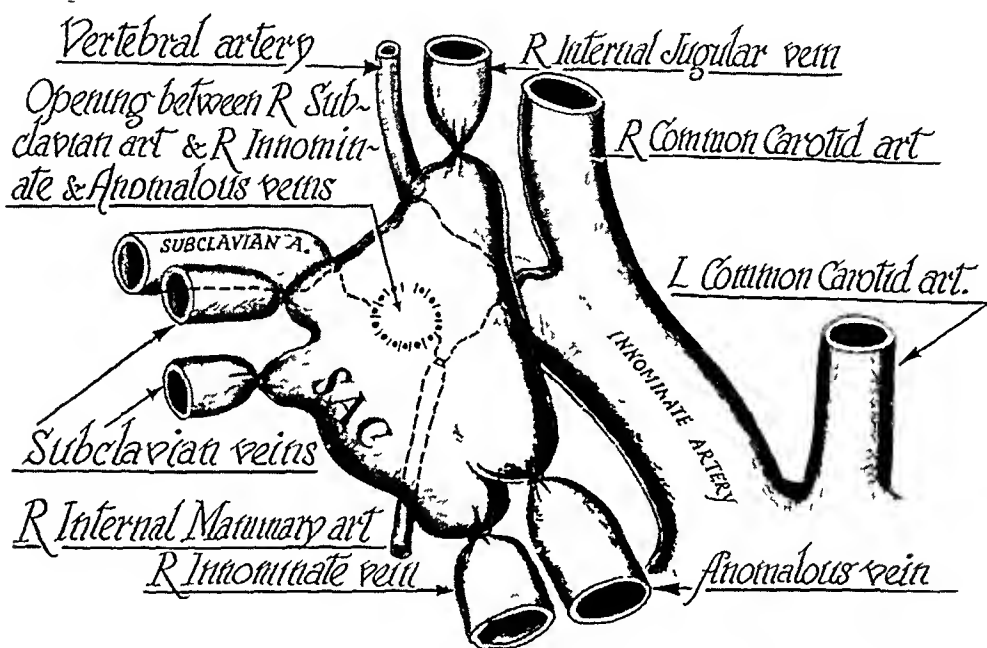


FIG 7—Condition found at operation in Case 4. Fistula between subclavian artery and innominate vein. The points of ligation or ligation and division of the various arteries and veins are shown.

sation in the right sternoclavicular area, numbness in the right ulnar distribution and hyperhidrosis of the right hand

There was a continuous thrill centered over the sternoclavicular area and a continuous bruit so loud that it masked all respiratory sounds in the chest. The bruit and thrill could not be obliterated by digital compression. There was excessive sweating and slightly diminished temperature of the right hand, and slight reduction in oscillometry and blood pressure in the right upper extremity as compared with the left. Blood pressure was 142/76. Electrocardiogram was normal and roentgenogram not remarkable except for a metallic foreign body under the sternal end of the right clavicle. It was thought that the patient had an arteriovenous fistula involving the first portion of the subclavian vessels.

Exploration was carried out on June 13. The condition found is illustrated in Figure 7. The fistula existed between the origin of the subclavian artery and the innominate vein just where it received the internal jugular and two subclavian veins. A large anomalous

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vein emptied proximally into the vena cava. It was possible to ligate the 5 veins involved, the subclavian artery just as it emerged from the innominate and just distal to the fistula, and the vertebral and internal mammary arteries which originated in proximity to the fistulous opening. The veins as well as the distal subclavian artery were divided between transfixing ligatures and a part of the venous sac was excised.

Convalescence was smooth and excellent circulation was maintained in the right upper extremity.

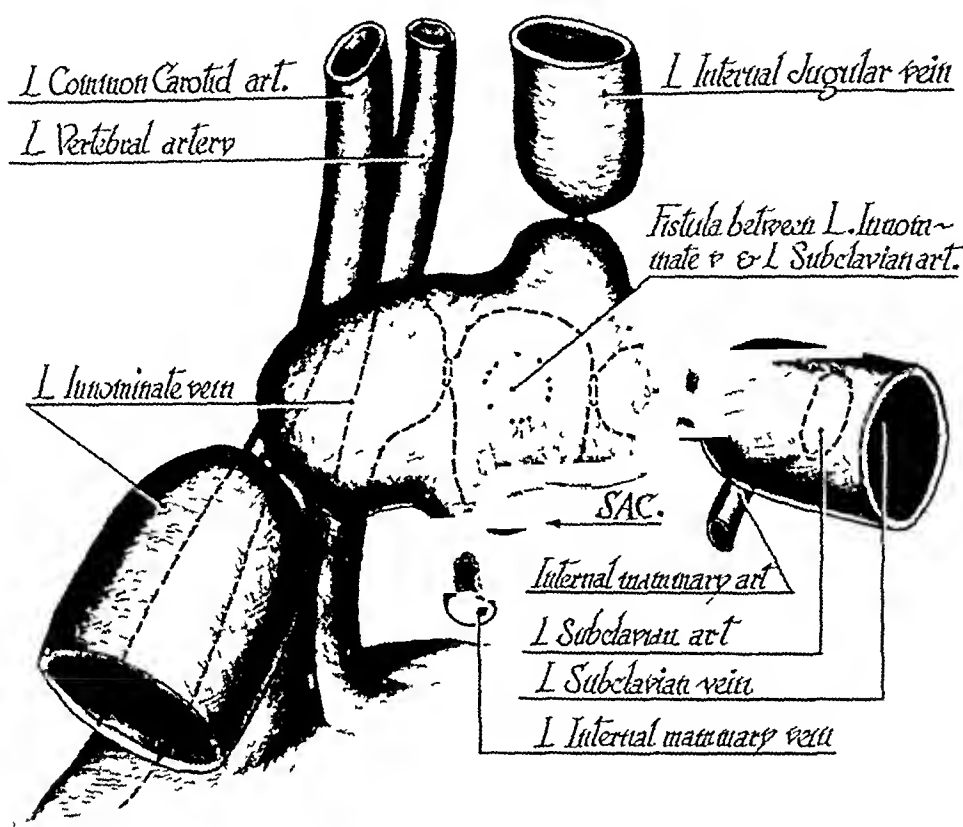


FIG 8—Condition found at operation in Case 6. Arteriovenous and saccular aneurysm of subclavian artery and innominate vein.

Case 5—The patient was a 24-year-old soldier who on January 24, 1945, received shell fragment wounds of the abdomen, chest, hands, right forearm, arm and leg. The wounds were débrided, an exploratory laparotomy was performed, and numerous thoracenteses were done for bilateral hemothorax. He arrived at the Mayo General Hospital on May 21, 1945, with a diagnosis of arteriovenous fistula.

There was a continuous murmur audible over the upper anterior chest and maximal over the right border of the sternum at the level of the second interspace. No thrill was palpable. There were no circulatory disturbances of the extremities. Blood pressure was 124/60. Electrocardiogram was normal. Roentgenograms of the chest revealed a mass in the anterior superior mediastinum. The impression was that the patient had an arteriovenous and saccular aneurysm probably involving the innominate vessels.

He stood carotid compression without symptoms. It was impossible to close the fistula by compression and hence to test the collateral circulation to the right upper extremity. A dorsal sympathectomy was performed on July 5.

Mediastinal exploration was carried out on September 17. The upper portion of the

mediastinum was filled with a firm, pulsating aneurysmal mass about 7 by 6 cm in size, associated with a continuous thrill. The carotid and subclavian arteries and the internal jugular veins could be identified at the upper pole of the mass on either side, they seemed to emerge from the aneurysm itself. The superior vena cava was free proximally but it disappeared into the mass about 2 cm from its cardiac end. The superior border of the arch of the aorta was fused with and partly buried beneath the mass. The innominate vessels were not visible. It was felt that the arteriovenous and saccular aneurysm involved the innominate vessels, the origins of both carotid and subclavian arteries, as well as the terminal portions of the internal jugular veins, the superior vena cava, and possibly the arch of the aorta. Surgical extirpation appeared to be impossible. The wound was closed in the usual manner.

Convalescence was uncomplicated. He has remained in fairly good health and is able to do light work on a farm.

Case 6—The patient was a 24-year-old soldier who had been injured in the left thigh, leg, arm and scapular area by shell fragments on December 10, 1944. Wounds were debrided and the left upper and lower extremities were placed in plaster casts. The femoral fracture progressed satisfactorily but osteomyelitis of the tibia and fibula at the site of the compound fracture was present upon admission to the Mayo General Hospital in May. An arteriovenous fistula in the left sterno-clavicular region had been recognized shortly after injury. There were no complaints referable to the fistula. There was weakness of the left upper extremity and an ulnar paralysis.

There was a continuous thrill and a loud continuous bruit over the left anterior chest wall and the left side of the neck, most prominent in the sterno-clavicular area. Neither bruit nor thrill could be obliterated by digital compression. The left fingers were cooler than the right and pulses and oscillometric readings were much reduced in the left upper extremity as compared with the right. After a period of treatment on the orthopedic service, and left ulnar neurotomy, the patient was returned to the vascular service on August 22. Because of the evidence of reduced circulation in the left upper extremity and the impossibility of testing the collateral circulation, a dorsal sympathectomy was performed on August 30.

On September 18 mediastinal exploration was undertaken with a preoperative diagnosis of arteriovenous fistula of the proximal portion of the subclavian vessels. The condition found is illustrated in Figure 8. There was a fistula between the subclavian artery just distal to the vertebral branch and the innominate vein near its distal end. The vessels were isolated proximally and distally and the fistula was dissected free and transfixed. It was then discovered that there was in addition a saccular aneurysm arising from the posterior surface of the artery opposite the fistulous opening. The artery was badly damaged over a considerable distance. Consequently the artery was ligated on either side of the aneurysm, the innominate, internal jugular, subclavian and internal mammary veins were ligated and divided, and the specimen was excised.

Convalescence was uneventful and the patient was returned to the orthopedic service for further treatment for the osteomyelitis in the leg.

SUMMARY AND CONCLUSIONS

1 In any contemplated excision of an aneurysm or arteriovenous fistula it is essential to isolate the vessels proximal and distal to the lesion before directly attacking the lesion itself. This necessitates ample exposure.

2 Vascular operations upon the vessels in the anterior superior mediastinum require resection or division and retraction of the overlying bony framework.

3 An operative procedure which has given excellent exposure without

injury to the underlying structures and which yields a good cosmetic and functional result is presented and is illustrated by several case reports

4 Although each case must be individualized and the proper operative approach selected, it is believed that the procedure outlined will be found suitable for many explorations in the anterior superior mediastinum

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BRONCHIOGENIC CYSTS OF THE MEDIASTINUM

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A VARIETY OF CYSTS occur in the mediastinum and the vast majority are congenital in origin.⁶ Some arise as a result of developmental aberration of the primitive foregut. The term bronchiogenic is usually applied to cysts arising from the respiratory system, whereas those derived from the digestive tract are termed esophageal or gastric. There is no sharp line of distinction between the bronchiogenic cysts and those arising from the digestive tube. This paper, nevertheless, will be concerned chiefly with the bronchiogenic group. The subject of intrathoracic cysts arising from the digestive tract has been recently discussed by Schwartz and Williams³⁵ and by Ladd and Scott.²⁰ Bronchiogenic cysts of the mediastinum are closely related to aberrant pulmonary tissue¹¹ and congenital intrapulmonary bronchial cysts.¹⁵ As some of the clinical features as well as the therapeutic problems of bronchiogenic cysts of the mediastinum may differ from the intrapulmonary cysts, it seems advisable to consider the former as a separate group. The intrapulmonary bronchiogenic cysts will not be considered in this paper, as the subject has been previously discussed elsewhere^{22, 23} and reviewed by Pugh.²⁹

Until recently bronchiogenic cysts of the mediastinum have been considered to be rare, but with more frequent roentgenologic examinations of the thorax and the widening scope of thoracic surgery, many more cases of this type are being observed. Although some authors have believed the bronchiogenic mediastinal cyst to be usually asymptomatic, an analysis of all the case reports, both in the pathologic and surgical literature, suggests that a considerable number eventually cause symptoms of varying degree. Occasionally a bronchial cyst of the mediastinum causes death in early life by compression of the trachea or main bronchi.

Bronchiogenic cysts of the mediastinum which do not cause symptoms in early life may be found by chance on roentgenographic examination in adult life, or may be an incidental finding at autopsy. In some instances, however, due to the gradual increase in the size of the cyst with resultant pressure on adjacent structures, symptoms of varying degree may lead to clinical investigation and diagnosis. During a two-year period (1943-1944) five patients with a bronchiogenic cyst of the mediastinum were operated upon by the author on the Thoracic Surgical Service of the Memorial Hospital and three additional cases have been operated upon elsewhere.* The eight cases illustrate various features of bronchiogenic mediastinal cysts and some problems in the surgical therapy of this lesion. In addition to reporting these eight cases, the literature of mediastinal cysts is reviewed and the collected cases have been analyzed.

* Two cases at Lenox Hill Hospital and one case at Kings County Hospital

CYSTS OF THE MEDIASTINUM

ORIGIN OF MEDIASTINAL BRONCHIOGENIC CYSTS

A brief discussion of the embryology of the primitive respiratory tract may clarify the problems associated with the development of bronchiogenic cysts³ The respiratory tract has a common origin with the esophagus from the primitive foregut As a result of the lateral invasion of two septa, the foregut is divided into a ventral and a dorsal component These two masses of cells eventually are separated from one another and the dorsal component forms the esophagus, while the ventral component forms the trachea and major bronchi The close embryological association of the respiratory tract



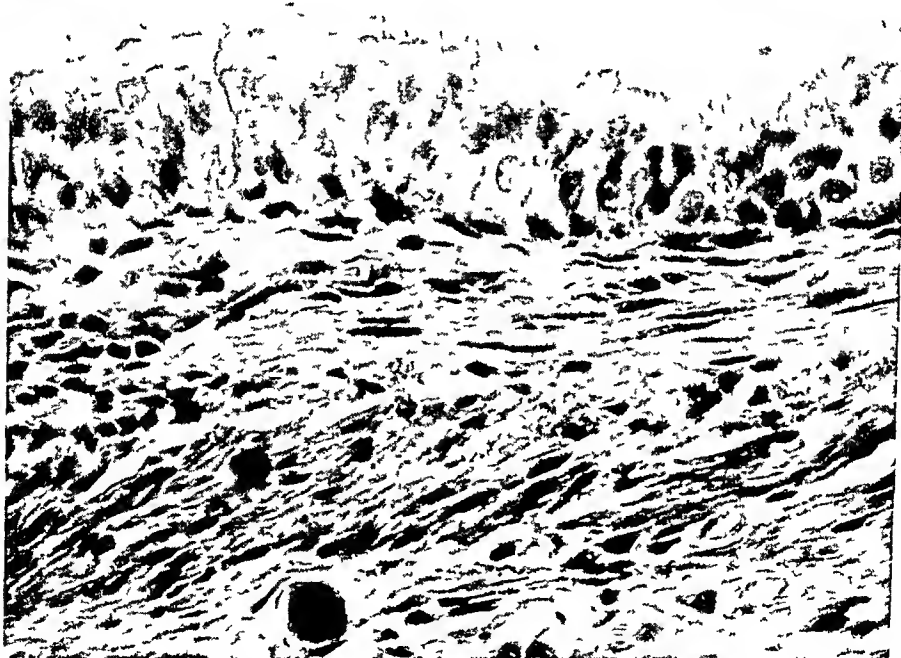
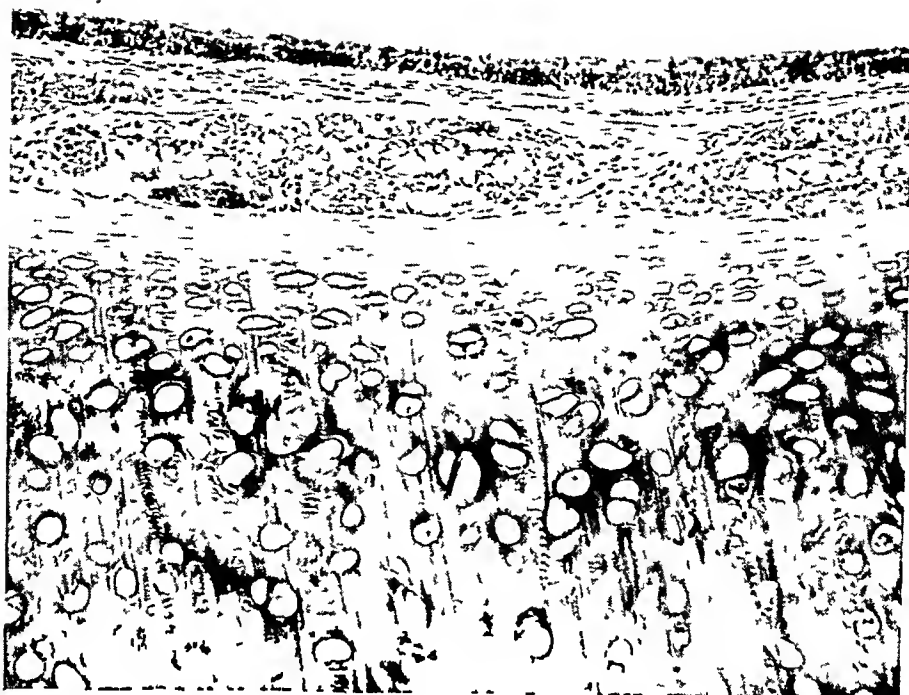
FIG 1—Bronchiogenic cyst Appearance of inner aspect after evacuation of fluid contents Note the thin wall and the numerous trabeculations

with the primitive foregut indicates the possibility of a close association of developmental anomalies of these two structures

Bronchiogenic cysts result from an abnormal budding or branching of the tracheobronchial tree³⁴ If the continuity with the bronchial tree is maintained, the cyst is usually intrapulmonary or in intimate association with the lungs If the mass of cells becomes separated from the tracheobronchial tree, there may be no continuity with the bronchial lumen Such cysts gradually increase in size because of the distension produced by the secretion within the cavity

An analysis of the literature reveals a difference of opinion concerning the

A



B

FIG 2—A Photomicrograph of wall of bronchiogenic cyst. Appearance similar to wall of a bronchus. Ciliated columnar epithelium, mucous glands, cartilage, and muscle fibers are present.

B Higher magnification of cyst wall clearly demonstrates the ciliated columnar epithelium.

stage in embryonic development at which aberrations occur which result in bronchiogenic mediastinal cysts. Although the wall of a typical bronchiogenic cyst is composed of structures similar to that of the bronchial wall, in an occasional case components of the digestive tract are also found in the same cyst wall³⁷. The latter finding has been advanced as an argument in favor of the contention that the abnormal development begins at an early stage of the embryo before the separation of the respiratory tract from the primitive foregut. Whereas the majority of bronchiogenic cysts are found in relationship to the trachea or main bronchi, in an occasional instance the cyst may be in close association with the esophagus or even the vertebral bodies. These findings lend support to the contention that in at least some instances the misplacement of cells occurred at a relatively early stage of development.

PATHOLOGY

Bronchiogenic cysts usually appear as a single spherical cystic mass, but the cyst may be lobulated, or occasionally there is a chain of cysts. On section the cysts are often single, but may be multiloculated or contain several non-communicating cavities of varying size. The inner aspect is frequently trabeculated (Fig 1). The cyst wall is usually relatively thin, although there may be thicker portions. The cyst is lined by ciliated columnar epithelium and the wall contains mucous glands, cartilage, elastic tissue and smooth muscle (Fig 2A and B). In some instances the cartilage or mucous glands may be absent. The uninfected cyst usually contains a thick, white mucoid material. Even in the absence of infection the cyst contents may be dirty brown⁴⁰ and sometimes closely resembles thick, purulent material. The cyst only rarely has any actual communication with the lumen of the tracheobronchial tree. Secondary infection may produce an inflammatory process which results in destruction of the lining epithelium and may render definite recognition of the bronchiogenic origin uncertain, especially if cartilage is not present in the cyst wall. The cyst may have a definite attachment to a portion of the tracheobronchial tree, but in some instances, although it is adjacent to a bronchus, there may be only loose areolar tissue between the two structures. Occasionally, a bronchiogenic cyst has no apparent connection with the tracheobronchial tree. If the bronchiogenic cysts of the mediastinum are segregated according to their location, certain embryologic, pathologic, and clinical features characteristic of each group may be noted. Bronchiogenic cysts may be arbitrarily divided into the following groups:

- 1 Paratracheal
- 2 Carinal
- 3 Hilar
- 4 Paraesophageal
- 5 Miscellaneous

1 Paratracheal Group Several instances of a bronchiogenic cyst attached to the tracheal wall have been reported. A characteristic example of this type

of cyst is illustrated by Case 1. The cyst is usually attached to the right lateral tracheal wall a short distance above the bifurcation of the trachea. The site of attachment of the cyst is similar to the point of origin of the first lateral bronchus of some mammals. Moreover, diverticuli of the trachea have been reported in this same location.⁷ The evidence suggests that bronchial cysts of the trachea occur as a persistence of a structural characteristic of lower forms. The embryology of the tracheobronchial tree in the pig has been thoroughly studied by Flint¹⁰. He has demonstrated that the lateral bronchial branch from the trachea ordinarily occurs only on the right side. The instances of bronchiogenic cysts in which the cyst had an intimate association with the tracheal wall have almost all been on the right side. An analysis of these data leads to the conclusion that this type of bronchiogenic cyst is explained on the basis of the rudimentary development of a first lateral bronchial branch from the trachea. Blackader and Evans⁴ reported a paratracheal bronchiogenic cyst which compressed, but was not attached to, the left side of the trachea, and which caused the death of a nine-months-old boy.

2 *Carinal Group*. A number of cases in which the bronchiogenic cyst was located near or just beneath the bifurcation of the trachea have been reported. In some instances there was a definite strand-like attachment extending to the carina.¹⁸ In other cases the attachment was to one of the larger bronchi, whereas in still others the attachment to the bronchial tree was not definitely demonstrable. The frequency with which small bronchial cysts occur in the subcarinal area suggests the possibility of a relationship with other types of congenital anomalies. The bronchiogenic cysts often have a definite attachment to the carina. In some instances there is also an attachment to the anterior esophageal wall, or the cyst may be in the esophageal wall in this region. The location of these cysts corresponds closely with the most common site of congenital tracheo-esophageal fistula. The frequency of embryologic aberrations in this region is striking. The subcarinal bronchiogenic cysts may well represent a pinching off of a group of cells in the communicating channel between the primitive foregut and tracheobronchial tree. The bronchiogenic cyst arising in the carinal area may cause pressure on either the right or left main bronchus, or both.²⁵ If the cyst is large, it may also press on the lower trachea. The cyst may be relatively small and still cause considerable compression of the air passage, due to its rather confined location. Most of the reports of this type of cyst are to be found in the pathologic literature because the diagnosis was unsuspected before death.¹² The majority of the patients died within the first year of life, due to pulmonary complications secondary to compression of the tracheobronchial tree. Although no successful surgical removal of a bronchiogenic cyst in this location in an infant has been reported to date, the lesion should be amenable to surgical therapy if the correct diagnosis were made. In a discussion of the clinical features of this group of bronchiogenic cysts, the clinical picture which should suggest the possibility of the existence of the lesion will be outlined. Whereas some cysts in the same location, chiefly due to their small size, have been chance findings

at autopsy in late adult life, a large percentage of the cases that have been published have caused serious, if not fatal results from secondary pulmonary complications

3 *Hilar Group* The majority of bronchiogenic cysts which are diagnosed in the later part of childhood or in adult life are located in the hilar area and have an attachment to one of the main or lobar bronchi. In some instances the attachment to the bronchus is well defined, whereas in other cases only connective tissue strands bind the cyst wall to the bronchus. As the cyst increases in size, it projects into the pleural cavity²⁴

Because of its close proximity to the main bronchus, it may cause compression of the main stem or one of the lobar bronchi. The secondary pulmonary changes which may occur will be described under the clinical findings. A considerable portion of a large cyst may be in close proximity to the pericardium and the cyst may project between the various hilar structures of the lung. In one of my patients there was an anomalous distribution of the hilar structures of the right lower lobe and the cyst was intimately associated with these structures and displaced them to a considerable degree. In this case there was an extension of the cyst across the mediastinum almost into the opposite hemithorax.

The bronchial cysts occurring in the hilar area are embryologically closely related to aberrant pulmonary tissue and anomalous accessory lobes of the lung. A review of the subject of aberrant intrathoracic pulmonary tissue has been presented by Friedlander and Gebauer¹¹

Secondary infection of the bronchiogenic cyst may result in considerable destruction of the cyst wall, rendering identification difficult. Moller²⁷ has reported a case of bronchiogenic cyst which ruptured into the tracheobronchial tree with the development of secondary infection. The cyst was in an unusual location, in that it lay in the anterior mediastinum. At operation the communication between the cavity of the cyst and the bronchial tree could not be demonstrated.

4 *Paraesophageal Group* Some bronchiogenic cysts may be in close relationship with the esophagus and have little or no apparent connection with the tracheobronchial tree. In some instances the bronchiogenic cyst is merely in close proximity or loosely attached to the wall of the esophagus. In other instances, however, the cyst is entirely within the walls of the esophagus and bulges into the esophageal lumen, only the mucous membrane of the esophagus covering the inner aspect of the cyst wall. If an intramural esophageal cyst is lined by ciliated columnar epithelium but contains no cartilage within its wall, the bronchiogenic origin may be seriously questioned^{26, 19}. Cysts of this type located in the lower esophagus near the cardia have been reported by v Wyss,³⁹ Zahn,⁴² Rau,³⁰ Tresp,³⁸ and Westenryk.⁴¹ Robbins³² reported a bronchiogenic cyst within the wall of the esophagus which contained cartilage, and was lined by ciliated columnar epithelium. A number of cases have also been reported in which a cyst lined by ciliated columnar epithelium was found attached to the outer portion of the esophagus. In several of these same cases

a well-defined double muscle layer was present in the wall of the cyst⁹ In one of my cases (Case 2) the cyst extended for a considerable distance parallel with and to the right of the esophagus There were three separate cyst cavities extending from the level of the thoracic inlet down beneath the arch of the vena azygos to the level of the pulmonary hilum The paraesophageal location of the cyst in this case, as well as the thick double layer of muscle in the wall, suggested a re-duplication of the alimentary tract Moreover, no cartilage was found in the cyst wall Although the lining of the cyst was typical ciliated columnar epithelium suggesting a bronchial origin, the presence of ciliated columnar epithelium lining the esophagus at one phase of embryological development makes the matter inconclusive

5 *Miscellaneous Group* Occasionally a bronchiogenic cyst is found in a very unusual location Two cases have been reported in which the cyst was found within the pericardium^{17, 28} Rusby and Sellors³³ reported a case of bronchiogenic cyst associated with a congenital deficiency of the pericardium The patient had symptoms which were attributed to the bronchial cyst This was removed at operation which was followed by an uneventful recovery A defect in the pericardium was also present in one of my cases (Case 7) The bronchiogenic cyst was located anteriorly in close proximity to the site of congenital absence of a portion of the upper part of the pericardium Guillery¹³ found a cyst lying on the anterior aspect of the thoracic spine and extending into the vertebral bodies, together with a smaller cyst of similar type behind the vertebral bodies In this case no cilia were demonstrated on the cylindrical epithelium which lined the cyst The muscle layers were more suggestive of the wall of the digestive tract than that of the respiratory system The infant had died at the age of three months The portion of the cyst which projected forward from the thoracic vertebrae had caused compression of the bronchi, especially on the right side

Seybold and Claggett³⁶ reported a presternal cyst lined by ciliated, pseudo-columnar epithelium, which was located in the subcutaneous tissues at the sternal angle The walls were thin and contained mucous glands, cartilage, vessels and nerves This cyst bore a striking similarity to a bronchiogenic cyst of the mediastinum, and it was considered that the cyst had migrated into a presternal position The underlying sternum showed no abnormality

SYMPTOMATOLOGY

In the absence of infection, the symptomatology of bronchiogenic cysts depends chiefly on the size and location of the mass In some instances there are no symptoms referable to the lesion, and the presence of the cyst is only demonstrated by a routine roentgenogram of the chest, or is a chance finding at autopsy In general, the symptoms presented are those produced by compression of the tracheobronchial tree In some of the patients in whom a bronchiogenic cyst was removed because of the finding of an undiagnosed mass

on a roentgenogram, the symptoms were rather vague and not characteristic, so that without a follow-up study it is difficult to ascertain whether or not the symptoms were caused by the cyst. When secondary infection supervenes, the symptoms resemble those of intrathoracic suppuration, particularly those of mediastinal or pulmonary abscess. Occasionally there is prominence of the chest wall in the region of the cyst. The symptomatology in special groups will now be discussed.

1 *Paratracheal Group* In the few cases of this type that have been reported, no characteristic symptoms have been present. One case had previously had an empyema on the same side, but at the time of operation ten years later no infection was present. Due to its location, the cyst may cause considerable narrowing of the trachea, as is illustrated in Case 1, but the compression is usually insufficient to cause serious obstruction.

2 *Carinal Group* When the bronchiogenic cyst is located just beneath the bifurcation of the trachea and causes symptoms in early life, the history may indicate some respiratory difficulty at or shortly after birth. In other cases nothing abnormal is noted until a respiratory infection develops. The natural tendency is to ascribe the symptoms to the pulmonary infection. Sometimes without such an evident precipitating factor, difficulty in breathing may be noted. Clinical and roentgen examination may indicate either obstructive emphysema or atelectasis, depending upon the degree of bronchial obstruction. Wheezing may be present, a croupy cough is sometimes noted. Varying degrees of dyspnea and cyanosis may develop. Progressive respiratory difficulty ensues and frequently results in a fatal outcome.² Analysis of the literature suggests that in those cases in which the subcarinal type of cyst causes symptoms in early life, the mortality rate is extremely high.

In some infants noisy breathing or attacks of cyanosis, especially during crying, may have been noted since birth. At times expiratory stridor is present. If the wheezing has been present for a considerable period of time, an asthmatic condition may erroneously have been considered the explanation of the symptoms. Adams and Thornton¹ have reported a bronchiogenic cyst in this location which first caused symptoms in adult life when secondary infection supervened. Robbins³² reported a bronchiogenic cyst in an 18-year-old male which was located just beneath the carina. This cyst measured 8 x 6 cm and caused an irritating, non-productive cough apparently due to pressure on the main bronchus. Surgical removal was successfully carried out. Similar cysts have occasionally been chance findings at autopsy in adults.³¹

3 *Hilar Group* Bronchiogenic cysts arising in the area of the pulmonary hilum usually project a varying amount into the pleural space on that side. These lesions are often asymptomatic, but when symptoms are present, these are usually due to compression of a portion of the bronchial tree. Dull chest pain, dry cough, wheezing and frequent respiratory infections may occur. In occasional cases, such as in Case 4, moderate bronchial compression over a considerable length of time may cause chronic pulmonary infection which causes a productive cough. This same patient had slight discomfort on swal-

lowing, due to displacement of the esophagus by the cyst. In one of my patients there were no complaints prior to the accidental finding of the bronchiogenic cyst on a routine roentgenogram of the chest. Following removal of the cyst, however, the patient gained considerable weight and felt far better than he had for many years. Undoubtedly in this case the cyst was causing definite although unrecognized disturbance, probably due to the secondary changes in the lung which, however, had failed to cause cough or expectoration.

4 *Paraesophageal Group* When the bronchiogenic cyst occurs in close relationship with or within the wall of the esophagus there may be symptoms referable to that organ. Some dysphagia may be noted. The symptoms are similar to those encountered in benign tumors within the wall of the esophagus. Occasionally the lumen of the esophagus above the lesion is dilated. If the cyst is chiefly outside the wall of the esophagus, the patient may be asymptomatic.

5 *Miscellaneous Group* In the cases of bronchiogenic cyst of the mediastinum occurring in miscellaneous locations, the only characteristic symptom complex is that which occurred in the two cases of intrapericardial cysts. These patients died suddenly, apparently owing to pressure on a portion of the heart or great vessels.

DIAGNOSIS

Until the last few years a diagnosis of bronchiogenic cyst has rarely been made before operation or autopsy. In some instances the clinical and roentgenologic picture presents nothing sufficiently characteristic to differentiate the lesion from other types of mediastinal tumor. There are, however, certain clinical and roentgenologic features which may lead to either a probable or even in some instances, a definite diagnosis prior to operation.

1 *Paratracheal Group* As the clinical findings in this group are not characteristic the roentgen examination would seem to be the sole evidence upon which a diagnosis might be made prior to operation. Bronchiogenic cysts would have to be differentiated from other tumor masses in the upper mediastinum lying in close proximity to the trachea. A substernal thyroid, a thymic tumor, an intrathoracic hygroma, a serous cyst and an aneurysm are the chief lesions to be considered in a differential diagnosis. A substernal thyroid often surrounds the trachea to a greater extent than a tracheal cyst, which is usually located entirely to the right of the trachea. The borders of the mass as seen radiographically are generally more sharply defined in a cyst, as contrasted to a soft tissue mass such as a thyroid adenoma. Both lesions, however, may show calcification.

A thymic tumor may have a less well defined border on the roentgenogram, usually projects bilaterally from the mediastinum and is located more anteriorly. The upper limit of a paratracheal cyst will usually be above the level of the clavicle on the roentgenogram, whereas a thymic tumor begins below the clavicle and extends further downwards.

Differentiation of a bronchiogenic cyst attached to the trachea from an intrathoracic hygroma or serous cyst may offer real difficulty. If aspiration is performed, thick white or yellow mucoid material may be obtained from the bronchiogenic cyst in contrast to the clear watery fluid in the hygroma or serous cyst.

An aneurysm, particularly of the innominate artery, might give a somewhat similar roentgen appearance. Angiocardiography may definitely establish whether the mass is of vascular origin. An aneurysmal sac filled with a laminated clot, however, will not be delineated by the opacified blood, and therefore this diagnostic procedure does not always give positive information, particularly if the degree of opacification is somewhat unsatisfactory.

2 Carinal Group The diagnosis of the subcarinal bronchiogenic cysts, especially when producing symptoms in infants, has apparently been very difficult in the past. As mentioned in a discussion of the symptomatology, the picture is essentially that of a bronchial, or occasionally lower tracheal, obstruction. It is usually erroneously assumed that the obstruction is produced by an inflammatory process within the air passages, whereas actually the pulmonary infection is secondary to bronchial compression by the cyst from without. A roentgenogram of the chest may give no indication of the presence of a mediastinal tumor because the cyst is relatively small and is completely hidden in the mediastinal densities. If the possibility of a cyst were borne in mind, an oblique film might be helpful in delineating the mediastinal mass, provided the superimposed densities from the pulmonary infection do not cause obscuration.

A clue to the true nature of the lesion may be obtained by bronchoscopic observation in certain cases. If bronchoscopy shows no endobronchial lesion but external compression of the lower trachea, or one or both main bronchi, a mediastinal tumor of some type must be ruled out. Other lesions, however, may also cause extrinsic pressure on the lower trachea. Congenital anomalies of the large vessels may be associated with obstruction to trachea or esophagus, or both. Operative intervention might be advisable in either situation.

3 Hilal Group Apparently the most frequent preoperative diagnosis in patients with bronchiogenic cyst reported in the literature has been mediastinal dermoid. A point which should be of considerable aid in differentiating these two lesions is that the dermoid tumors arise in the anterior mediastinum, whereas the bronchial cysts are more frequently located in the posterior mediastinum. A few dermoid cysts have been reported as arising in the posterior mediastinum but on reviewing these cases, most of them are found to be instances of bronchiogenic cysts rather than mediastinal dermoid.¹⁴ In some instances bronchiogenic cysts have been confused with neurogenic tumors. On the lateral roentgenogram neurogenic tumors are seen to be located in the costovertebral portion of the thorax, whereas the bronchiogenic cysts are in the posterior mediastinum anterior to the vertebral bodies.

Robbins³² has recently reported the roentgenologic findings in several cases of bronchiogenic cysts. He points out that bronchiogenic cysts may move

with respiration and also may change shape with respiration, indicating their cystic nature and relationship with the tracheobronchial tree. This finding may be of aid in differentiating bronchiogenic cysts from certain other mediastinal tumors. Dermoid cysts have a rather stiff wall and usually do not change contour with respiration. Included in Robbins' report are several cysts in which the histopathologic findings do not definitely demonstrate the origin of the cyst. The author included these cases because he thought they may be of value in linking the other cases of so-called simple or unclassified cysts of the mediastinum into one group. Whether these other cases are actually of similar origin to true bronchiogenic cysts cannot be stated at this time. In two of the cases the cyst was located in the anterior mediastinum in close relationship to the pericardium and diaphragm. In neither of these cases was the cyst wall entirely typical of a bronchiogenic cyst, and the radiologic and histologic findings suggested the possible diagnosis of pleural cyst of the type discussed by Lambert²¹. Also included in the report of Robbins are cases of bronchiogenic cysts within the substance of the lung and an intrapulmonary cyst-like lesion secondary to chronic abscess, which are not to be confused with the cases considered in the present paper.

Rarely a mediastinal bronchiogenic cyst perforates into the lung, with resultant bronchial communication. Then the roentgenologic and clinical picture simulates either a mediastinal or pulmonary abscess. As bronchiogenic cysts are closely related to aberrant pulmonary tissue, a cyst-like cavity lined with respiratory epithelium may be formed as a budding from the bronchial tree. Harrington¹⁵ has reported a case in which the azygos lobe consisted of a sac similar to the wall of a bronchiogenic cyst. There was a small bronchial communication with the upper lobe. The connection with the tracheobronchial tree permitted the partial evacuation of the cyst contents and resulted in the presence of a fluid level within the cyst cavity at one roentgenographic examination. A few other instances of bronchiogenic cyst of the mediastinum with a fluid level have been reported, but this finding usually indicates that the cyst is intrapulmonary.

4 *Paraesophageal Group* A bronchiogenic cyst may be in close association with the esophagus, or even the cardiac portion of the stomach. The lesion must be differentiated from solid tumors of the esophageal wall.

A considerable number of cases are on record in which a cyst lined by ciliated epithelium has been found within or in close association with the wall of the esophagus. In the majority of instances no cartilage has been found in the cyst wall, and therefore it is questionable whether they should be classified with the bronchiogenic group. Those cases without cartilage might be considered as having resulted from the pinching off of the cells from the esophageal wall itself, since the esophagus is lined by ciliated columnar epithelium at one time in its embryological development. The paraesophageal cyst lined by ciliated columnar epithelium should be differentiated from paraesophageal cysts which are lined by mucous membrane similar to that of the stomach or small intestine. Paraesophageal cysts lined by gastric mucosa may

secrete pepsin and acid which result in ulceration and even erosion of adjacent structures. Examination of the contents of the cyst may aid in the differential diagnosis of a paraesophageal bronchiogenic cyst from a thoracic gastric cyst. Both types can bear a similar relationship to the esophagus, and it would not always seem possible to make a differential diagnosis on the basis of clinical and roentgen findings alone. An analysis of the literature suggests that the thoracic gastric cysts are far more likely to lead to symptoms and surgical intervention in early life than the paraesophageal bronchiogenic group. Schwartz and Williams³⁵ collected ten cases from the literature and added two of their own. Half of the cases of thoracic gastric cysts caused symptoms or death within the first year of life, and only two of the 12 cases were over four years of age at the time of operation or autopsy. Probably the gastric mucosa secretes more rapidly and leads to more rapid enlargement of the cyst, with secondary compression of the lung. The mediastinal cysts of enteric origin usually project from the right side of the mediastinum, and although the bronchiogenic cysts are also more common on the right side, there is not the overwhelming predilection for the right side as is seen with those of enteric origin. No obvious sex predominance has been noted in either group. Robbins³² reported a case of a small bronchiogenic cyst which was located in the wall of the esophagus and appeared as an intramural, extramucosal lesion. The mucosal folds of the esophagus were preserved over the lesion and the mass was noted to move up and down with respiration and upward during the act of swallowing. The motion of the mass was similar to that of the esophagus. At operation the cyst was removed from the wall of the esophagus, and histopathologic examination showed respiratory ciliated epithelium, smooth muscle and cartilage in the wall of the cyst.

TREATMENT

In a monograph on mediastinal tumors published in 1940, Heuer and Andrus¹⁶ state that they had found in the literature 25 cases of mediastinal cysts. This group of cases apparently includes both bronchiogenic and esophageal cysts. In 12 instances an operation had been undertaken for possible removal of the cyst, but the tumor was excised in only 8 of these cases. In 5 instances the cyst was extirpated at the first operation and in 3 its removal followed drainage and marsupialization. Operation in the remaining 4 patients consisted either of drainage of the cyst or its partial removal. All but one of the reported cases in whom complete removal of the cyst was possible recovered, but one of them had a persistent bronchial fistula. The authors also reported a personal case in which recovery followed excision of the cyst. During the past few years several reports on the surgical extirpation of bronchiogenic mediastinal cysts have appeared. The recent increase in routine roentgenographic examination has been responsible for the finding of a large number of these cases in which the patient was asymptomatic. Bronchiogenic cysts of the mediastinum were considered rare a few years ago, but are known today to be one of the most common tumors of the mediastinum.

Adams and Thornton¹ reported three cases of bronchiogenic cyst of the mediastinum treated successfully by surgery. Brown and Robbins⁵ analyzed 12 cases of mediastinal cyst from the Massachusetts General Hospital. In 6 of the 12 cases the bronchiogenic origin of the cyst may be considered definite on the basis of the histologic appearance of the cyst wall, and in one additional case the gross findings at operation leave little doubt about the diagnosis. In the remaining cases the cyst wall contained no definite bronchiogenic elements.

It is often difficult definitely to diagnose the exact nature of a mediastinal tumor preoperatively. As mediastinal tumors in general should be removed if proper facilities are available and no contraindication exists, a failure to make a correct preoperative diagnosis is not necessarily a great disadvantage. Whereas a considerable number of the bronchiogenic cysts which have been reported in the literature caused few if any clinical symptoms, a sufficiently large percentage cause complications, especially secondary respiratory infections, to warrant surgical removal. Naturally, if the patient's general condition is such as to increase the hazard of surgical intervention, it may be best to merely observe the patient closely if it is considered quite certain that the lesion is a benign cyst.

The author recommends a posterolateral transpleural approach because of the impossibility of ascertaining preoperatively the various attachments of the cyst. A posterolateral approach permits access to all parts of the pleural space and mediastinum. It may not be possible to remove the cyst intact. If the patient has manifested no signs of infection preoperatively, and if the findings at operation do not suggest suppuration, opening of the cyst and evacuation of its contents in the course of its excision would not seem to be hazardous. One wonders whether some of the empyemas following the opening of a bronchiogenic cyst reported in the older surgical literature may not have been due to other causes than opening the cyst.⁸ In three of our patients the cyst was opened at operation and there was gross contamination of the pleural space, but no pleural infection ensued. In one patient, (Case 4) it would have been impossible to remove the cyst intact. Before the cyst was opened, it was felt that complete removal might not be possible because of the marked extension of the cyst through the posterior mediastinum to the contralateral side, and because of its close relationship to the pericardium. After the cyst had been opened and evacuated, with collapse of the walls, it was possible to define the limits of the cyst more accurately, and then remove the cyst wall by combined sharp and blunt dissection.

As the cysts are on a congenital basis, the possible presence of other anomalies must be borne in mind. In one patient (Case 4), there was an anomalous pulmonary vein to the right lower lobe which had to be carefully dissected from the cyst wall. The inferior pulmonary vein was many times its normal length and encircled the lower border of the cyst. If this vein had been injured a lobectomy would have had to be performed, in addition to the

removal of the cyst. Similar anomalies of the vascular system may be found in cases of intrapulmonary bronchiogenic cysts.

If complete removal of the cyst wall seems hazardous, it would seem permissible to leave a small portion *in situ*. Adams and Thornton¹ have utilized silver nitrate to destroy the remaining epithelial lining. Incomplete removal of a bronchiogenic cyst is not as likely to lead to complications as partial removal of gastric or dermoid cysts.



FIG 3—Case 1. Paratracheal type of bronchiogenic cyst. Note that upper border of mass does not descend from cervical region in manner commonly seen with substernal extension of a thyroid.

In the paratracheal bronchiogenic cyst, injury to the tracheal wall must be carefully avoided. In our case the cyst had a common wall with the trachea over an area of approximately 2 cm, with a direct continuation of cartilaginous rings from the tracheal wall into the wall of the cyst. These small cartilaginous fragments were removed level with the tracheal wall, but a very small portion

of the cyst wall was actually left adherent to the trachea. In this instance it was not deemed advisable to apply any escharotic to destroy the residual lining because of the danger of denuding the cartilage, and the development of a chondritis. Although there were some recesses in the attachment between cyst and trachea, careful probing failed to reveal any continuity with the lumen of the trachea.



FIG 4—Case 2. Bronchiogenic cyst projects laterally above right hilar region. Considerable scoliosis due to hemivertebrae is present.

In operations for mediastinal tumors it is a great advantage to get complete early expansion of the lung. For this reason all the residual air is aspirated from the pleural space through a catheter as soon as the chest wall has been rendered air-tight by closure of the muscles of the thoracic wall. The catheter is then withdrawn as a mattress suture is tied. In some instances closed drainage for a day or two may be desirable.

CYSTS OF THE MEDIASTINUM

Most of the serious complications in the small number of surgical procedures that have been carried out for bronchiogenic cysts occurred in the case reports of earlier years and were related to the technic of thoracic surgery in general at that time, rather than to any particular problems encountered in bronchiogenic cysts. Seven of my eight patients had an uneventful postoperative course. One patient, who had mild symptoms of hyperthyroidism prior to operation as well as considerable pulmonary infection from bronchial compression, had a rather stormy postoperative course. At operation the cyst wall was dissected from a large part of the pericardium. This operative manipulation, superimposed on a mild hyperthyroidism, apparently precipi-

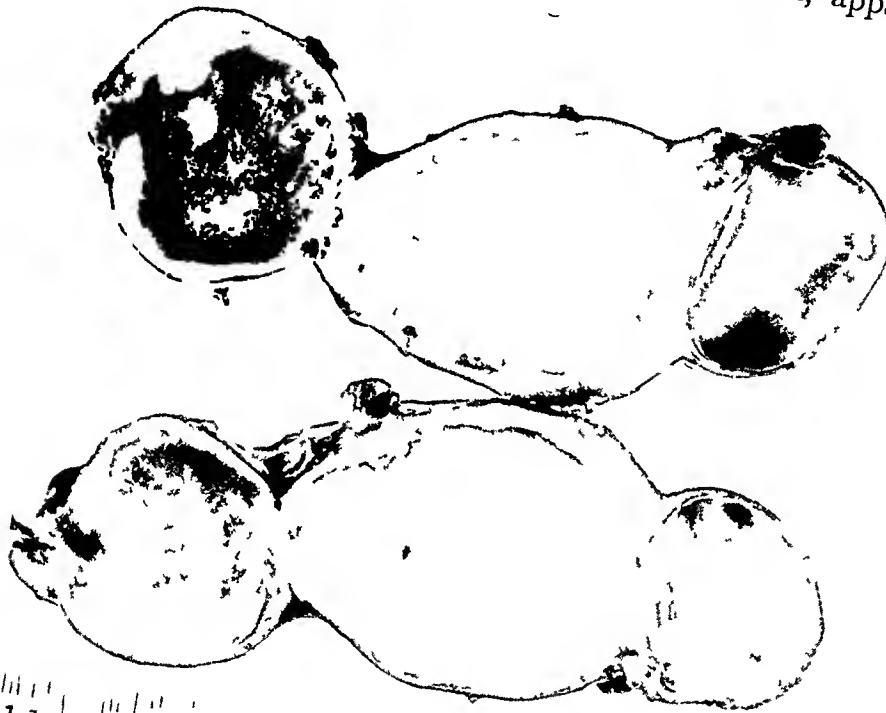


FIG 5—Case 2 Cut halves of gross specimen reveal three contiguous cysts

tated auricular fibrillation and flutter several days postoperatively. The cardiac abnormality rapidly responded to digitalis, and the patient had an otherwise uneventful course.

CASE REPORTS

Case 1—R W, #67865, male, age 26 years. Eight years prior to admission a routine chest roentgenogram had shown widening of the upper mediastinal shadow which was interpreted as an enlarged thymus. Subsequent roentgenograms showed little increase in the size of the shadow, until four months before admission to Memorial Hospital when another film showed a definite increase in the size of the mediastinal density. The patient did not complain of any chest pain, cough, expectoration, hemoptysis or dysphagia. There had been no change in weight and his general health was good. Physical examination

was essentially negative. Roentgenograms of the chest in postero-anterior projection (Fig 3) showed a shadow of considerable density projecting from the right upper mediastinal shadow. The shadow began a short distance above the upper margin of the clavicle and had a slightly irregular but sharply defined border, and extended down to the level of the vena azygos. The outer border of the shadow projected laterally several centimeters beyond the normal mediastinal density. The lateral film showed the density to occupy the upper posterior mediastinal area. There was considerable narrowing of the tracheal air column, especially from the anterior aspect. Roentgenogram of the esophagus revealed no abnormality and no compression by the tumor mass. Angiocardiographic studies showed no obstruction or displacement of the superior vena cava, and indicated that the mass was not an aneurysm. Bronchoscopic examination revealed only

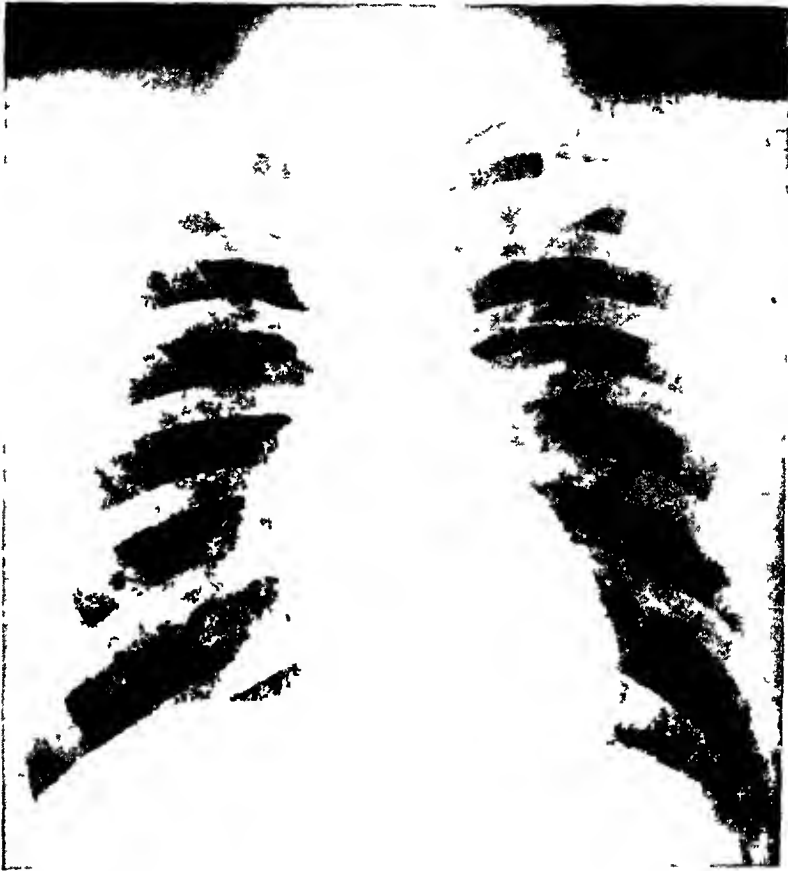


FIG 6—Case 3. Small bronchogenic cyst projects from right side of mediastinum just below level of inner end of clavicle.

compression of the trachea from the right lateral and anterior aspect. The basal metabolic rate was minus 16.

Operation—In the upper posterior mediastinal region there was bulging of the mediastinal pleura caused by an underlying tumor mass. The mass felt cystic with areas of calcification. The mass extended from the level of the thoracic inlet down to and slightly behind the vena azygos. It extended from the vertebral column to the innominate artery anteriorly. The tumor mass was loosely adherent to the superior vena cava and vena azygos and also rather closely associated with the vagus nerve. The mass, which measured approximately 10 x 6 cm., was adherent to the right lateral wall of the trachea throughout the greater portion of its extent, but was continuous with the tracheal wall

CYSTS OF THE MEDIASTINUM

for a distance of about 1 centimeter only. In this area the trachea and cyst wall had a common partition and cartilaginous plaques could be felt extending from the trachea into the base of the cyst. The wall of the cyst was thin and the cyst contained thick, white, non-odorous mucoid material. There was no sign of inflammation. The right lung appeared normal. The entire cyst was removed, with the exception of the small portion which had its wall in common with that of the trachea. No sinus into the trachea could be demonstrated with the aid of a fine probe. Although it was realized that the small portion left attached to the trachea had an epithelial lining, it was deemed inadvisable to apply any caustic because of danger of necrosis of the cartilage of the tracheal wall. The postoperative course was uneventful. Subsequent roentgenograms showed the tracheal air



FIG 7—Case 4 A Postero-anterior roentgenogram reveals area of density merging with right heart border. Note infiltration in right lower lung field.
B Lateral film shows mass in posterior mediastinum.

column to be of normal dimensions. Three years after operation the patient was asymptomatic.

The surgical specimen consisted of a cystic structure with thin walls containing many irregular pieces of cartilage. Most of the cyst wall measured only 2 mm in thickness. There were trabeculations in the interior of the cyst (Fig 1). Microscopic examination revealed that the wall of the cyst resembled the wall of a bronchus. The cyst was lined by ciliated columnar epithelium. The wall contained mucous glands, cartilage, smooth muscle and elastic fibers (Fig 2).

Case 2—T M #70313, male, age 23 years. Patient had apparently been well until three years previously, when he noted marked weakness and pallor. On examination a very severe anemia was found. A gastrointestinal series was done, but no evidence of peptic ulceration was discovered. A roentgenogram of the chest, however, revealed a mass in the right posterior mediastinal area. Five blood transfusions were given with resultant correction of the anemia. Because of the roentgenologic findings, a diagnosis of probable lymphosarcoma or Hodgkin's disease of the mediastinum was made at that

time, and the patient received radiation therapy. A total of 2,600 roentgens through two ports was given without significant change in the size of the tumor mass. Neither at that time nor in the following three years did the patient complain of any cough, expectoration or chest pain. There had been no dyspnea or difficulty on swallowing. Curvature of the upper thoracic spine had been present since infancy. The patient was referred to Memorial Hospital in 1943, three years after the mass in the chest was first discovered.

Physical examination revealed a well developed and nourished young male. There was rather marked scoliosis of the upper thoracic spine. Physical examination of the heart and lungs was essentially negative. Roentgenograms of the chest showed an irregular, somewhat rounded mass projecting from the right side of the mediastinum (Fig 4). Lateral film showed the mass to be in the posterior mediastinum close to the esophagus. A barium study revealed no displacement of the esophagus. There was scoliosis of the upper thoracic spine due to hemivertebrae.

Operation—Located in the posterior mediastinum, beginning at the level of the 7th rib and extending upward beneath the arch of the vena azygos to the thoracic inlet, was



FIG 8—Case 4 Photomicrograph of cyst wall shows ciliated columnar epithelium, smooth muscle, and mucous glands

a well encapsulated, lobulated, cystic tumor mass measuring about 10 cm in its greatest length. The tumor consisted of three apparently separate cystic areas which were attached to each other (Fig 5). The cystic tumor was not attached to the trachea, but was more closely associated with the right lateral esophageal wall, although there was actually no definite attachment to the esophagus. The tumor was removed after division of the azygos vein. The postoperative course was essentially uneventful. The patient has been well for three years.

The specimen consisted of a cylindroid-shaped tumor measuring 9 cm in length and 3 cm in diameter. There were two areas of constriction, so that the specimen had the appearance of being composed of three separate portions. The outer surface showed a fairly smooth capsule. On section, the mass was seen to consist of three definite, apparently non-communicating cysts. All three cysts were filled with semi-viscid, brownish, slightly oily material. The lining of the middle cyst and the upper cyst was smooth and shining, while the lower was finely granular. The cyst wall was firm and white, and

varied from 1 mm to 1 cm in thickness. Microscopic examination of the cyst wall showed all the component structures of a bronchial wall except cartilage.

Case 3—L F, #70359, male, age 18 years. Two months prior to admission a roentgenogram of the chest had shown a small, rounded density projecting from the right side of the mediastinum. The patient's only complaint was a slight, dry cough which he had had for several years and which he attributed to smoking.

Physical examination revealed a well developed and nourished young male. General examination was essentially negative. No thoracic abnormality could be detected by percussion or auscultation. Roentgenogram of the chest revealed a small, rounded shadow projecting out from the mediastinal density on the right side opposite the level of the arch of the aorta (Fig 6). The lung fields were clear. On the lateral film the mass could be vaguely outlined in the posterior mediastinum.

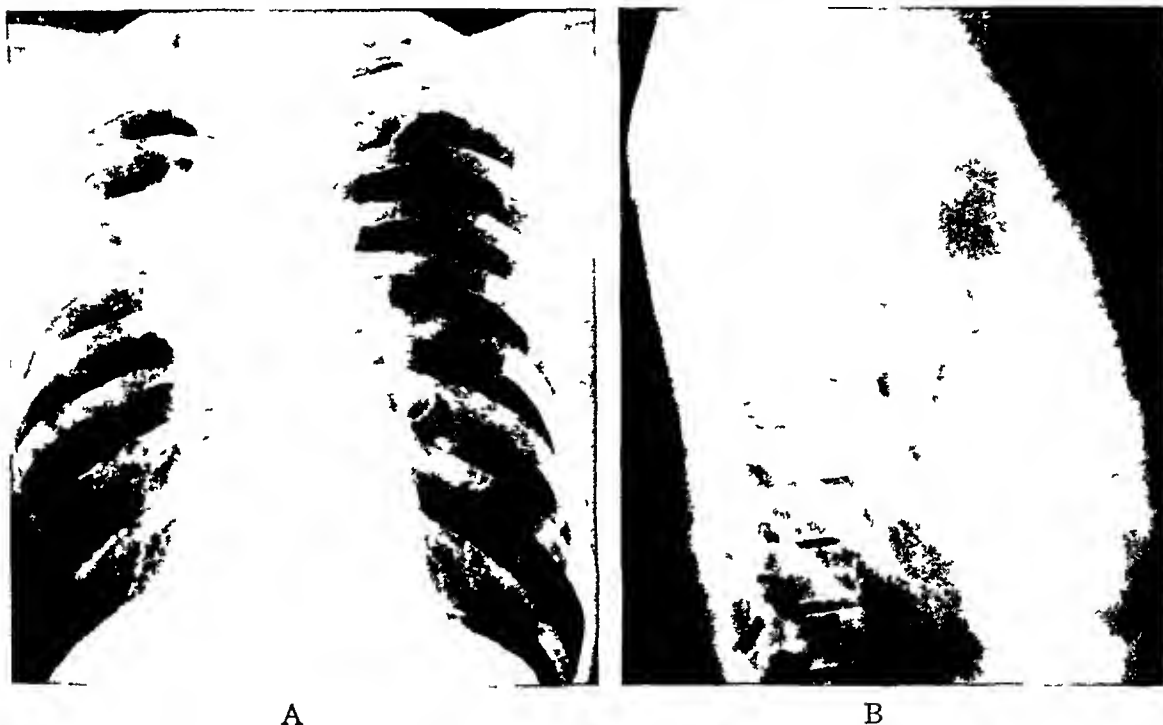


FIG 9—Case 5. A. Postero-anterior roentgenogram reveals mass in upper portion of right hilar region. Infiltration of the right upper lobe is evident.
B. Lateral roentgenogram reveals mass in posterior mediastinum.

Operation—A small multilobular, cystic mass was found just below the vena azygos and attached to the right main bronchus by a small pedicle. The cystic mass was loosely imbedded in the posterior aspect of the right upper lobe, from which it could be separated with ease. The cyst was grayish-white in appearance and the wall was very thin. The entire cystic mass was removed without difficulty. There was no communication between the cyst and the lateral aspect of the right bronchus, to which it was attached. The patient's postoperative course was uneventful. Patient has been well for three years, except for a slight cough.

The specimen consisted of a multilobulated mass 5 × 5 cm. Cut section showed the cyst to contain fluid which was jellied by previous fixation. The cyst was only a few millimeters in thickness. Microscopic examination of the cyst wall showed the various components of a bronchus.

Case 4—S B, #70577, female, age 33 years. This patient complained of increasing productive cough of two years' duration with mucopurulent sputum which was frequently blood-tinged. Slight dysphagia had been present for six months. For two months there

had been some pain in the right posterior thoracic region. Physical examination revealed a fairly well developed and nourished negro who did not appear acutely ill. Slight exophthalmos was present and the thyroid was symmetrically enlarged and firm. There was slight tremor of the hands. Examination of the lungs revealed some diminution of breath sounds at the right base posteriorly with occasional rales. The heart was slightly overactive, but no murmurs were heard. Roentgenogram of the chest showed a rounded density projecting from the right lower mediastinal shadow continuous with the density of the right cardiac border. There was scattered infiltration in the right lower lung field (Fig 7A). On a lateral film the mass was seen to lie in the posterior mediastinum (Fig 7B). Barium studies showed the esophagus to be displaced toward the left by the mass, but there was no obstruction. The basal metabolic rate was plus 10. It was thought that the patient had a bronchiogenic cyst with compression of the bronchial tree and secondary pulmonary infection with probable bronchiectasis. Bronchoscopy was not done preoperatively because of the patient's refusal following an unsuccessful attempt elsewhere. It was thought the patient had mild hyperthyroidism, but insufficient to contra-indicate the thoracic operation as the primary surgical procedure.



A

B

FIG 10—Case 6 A Roentgenogram shows double bronchiogenic cyst projecting from right upper mediastinum

B Tomograph shows more clearly the outline of two cysts

Operation—Avascular adhesions were present over the lower lobe. A cystic tumor mass occupied the posterior mediastinal area. Considerable difficulty was encountered in freeing the cyst from the inferior pulmonary vein which was elongated and closely associated with the wall of the cyst. During mobilization of the cyst it was ruptured and the contents removed by suction and sponge. The collapsed cyst wall was then dissected free by sharp and blunt dissection. The cyst wall varied from 1 mm to 4 mm in thickness. Microscopic examination revealed findings typical of a bronchiogenic cyst (Fig 8).

Two days postoperatively the patient developed auricular fibrillation which was treated by digitalization and Lugol's solution. Auricular flutter occurred for a brief period. It was thought that the cardiac complication was due to a combination of mild hyperthyroidism and extensive operative manipulation in the region of the auricles. The cardiac rate became normal within a few days. The patient also had considerable cough and expectoration, undoubtedly due to the preoperative pulmonary infection. The

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patient was discharged on the 16th postoperative day with the wound well healed. A thyroidectomy was performed later. During the three years since operation the patient has had a productive cough. A resection of the bronchiectatic portion of the lung has been recommended.

Case 5—J. L., 73999, male, age 35 years. In March, 1943, this patient had a left-sided pleurisy. A respiratory infection developed in January, 1944, following which he had frequent cough with moderate expectoration but no hemoptysis. In March, 1944, he had dyspnea on exertion. A routine chest roentgenogram, taken at an army induction center, revealed a mass in the right paramediastinal area. Patient was admitted to the hospital in May, 1944. Physical examination revealed a somewhat undernourished male who did not appear ill. Physical examination of the chest was essentially negative. Roentgenogram showed a right paramediastinal area of density with infiltration in the adjacent lung.

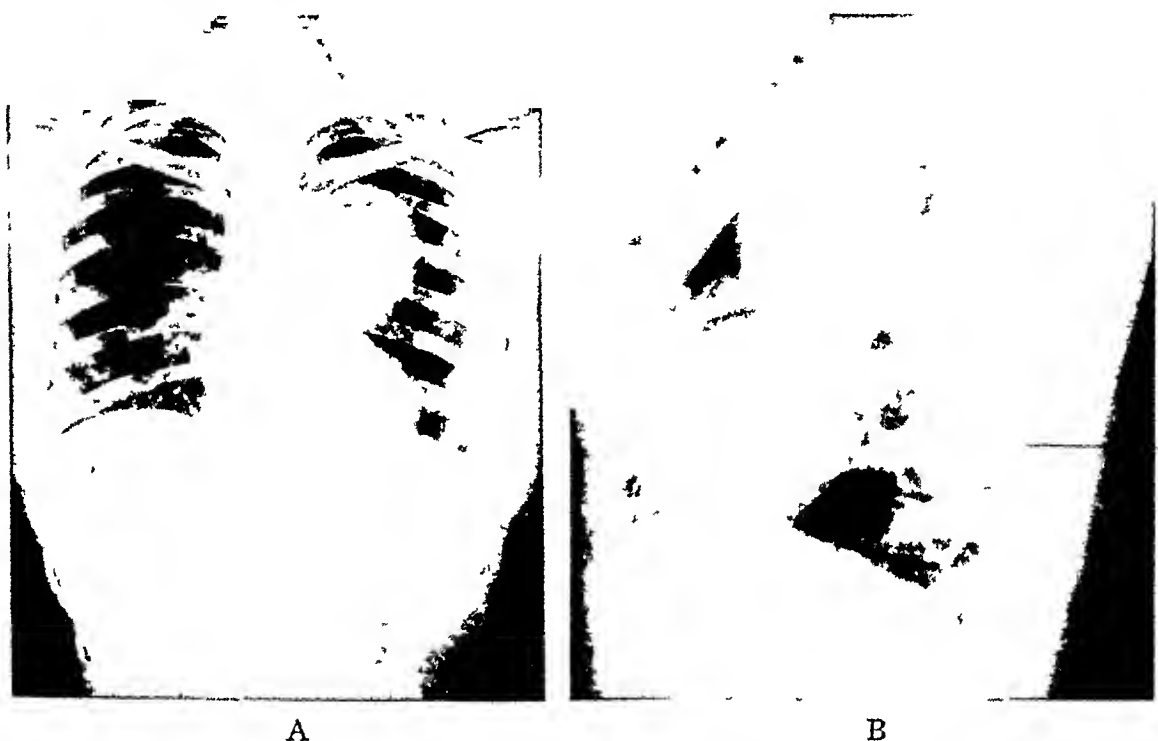


FIG 11—Case 7. A. Roentgenogram shows sharply demarcated mass projecting from left hilar region.

B. Lateral roentgenogram shows anterior location of cyst.

(Fig 9A) On lateral view the density was found to be in the posterior mediastinum. (Fig 9B) There was another small area of infiltration in the right upper lobe separate from the main mass. Fluoroscopy showed no pulsation of the mass. Bronchoscopy was negative.

Operation—A bronchiogenic cyst of the mediastinum extending into the right upper lobe was found. Evidence of considerable inflammation was present and there was a secondary bronchiectasis of the right upper lobe. The cyst and upper lobe were removed. The postoperative course was essentially uneventful. Within seven months after operation the patient had gained 30 pounds in weight, so that he weighed more than at any previous time. Roentgen-ray showed good expansion of the remaining portion of the right lung.

Pathologic examination showed the wall of the cyst to be largely replaced by granulation tissue, but a respiratory type of epithelium and areas of squamous metaplasia were also found. The excised lobe revealed bronchiectasis.

Case 6—H. S., Lenox Hill Hospital #108799, male, age 30 years. One year prior

to admission a mass was discovered in the paramediastinal region on a draft board roentgen-ray. Subsequent roentgenographic studies showed a double mass projecting out from the right side of the mediastinum. Patient had no cough or sputum, no chest pain, and his weight was increasing.

Examination revealed a robust male without abnormal physical findings. Fluoroscopy showed a density extending out from the right mediastinal area, which on lateral projection was in the posterior mediastinum. Roentgenograms showed two smooth, oval shadows of increased density, each about 5 cm in diameter, in the posterior portion of the right upper lobe near the mediastinum (Fig 10A and 10B). These shadows were in close contact with each other. Their anterior surfaces were in close relation to the right main bronchus. Bronchoscopy showed no evidence of narrowing of the trachea or bronchi but the bronchus of the right upper lobe was somewhat larger than normal.



FIG 12—Case 8 Large rounded area of density is present in the left upper portion of thorax

Operation—A dumb-bell shaped cystic mass was palpable in the hilar region of the right upper lobe. A small portion of this cystic mass could be seen on the posterior aspect of the hilum, but the major portion of the mass was covered by the medial portion of the right upper lobe with which it was intimately associated. The cyst projected for a considerable distance into the pulmonary parenchyma, although there was a line of cleavage between the cyst and the normal pulmonary tissue. The cyst was fairly thin-walled, had cartilaginous plaques within it, and contained non-odorous, greenish-gray, thick material. There was a strand-like thickening in the pulmonary tissue extending from the upper portion of the larger cyst to the apex of the lung, where there was a smaller cyst about 2 cm in diameter which contained material similar to the larger cyst. Otherwise the pulmonary tissue of the upper lobe appeared relatively normal. The middle

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and lower lobes were air-containing and appeared normal. The cysts were excised and the patient's postoperative course was uneventful.

Microscopic examination revealed the inner surface of the cyst to be partially lined with tall, ciliated columnar epithelium supported by a congested stroma which was richly infiltrated with round cells. Embedded in the stroma was an occasional small mucous gland. Portions of the cyst showed marked fibroblastic proliferation, and was densely infiltrated with inflammatory cells, including a few multinucleated giant cells of the foreign body type. In the deeper layers of the wall there was extensive fibrosis and a perivascular focal round cell infiltration.

Case 7—R. D., Lenox Hill Hospital #109712, female, age 22 years. On a routine chest roentgenogram taken during a physical examination, a mass was found in the left

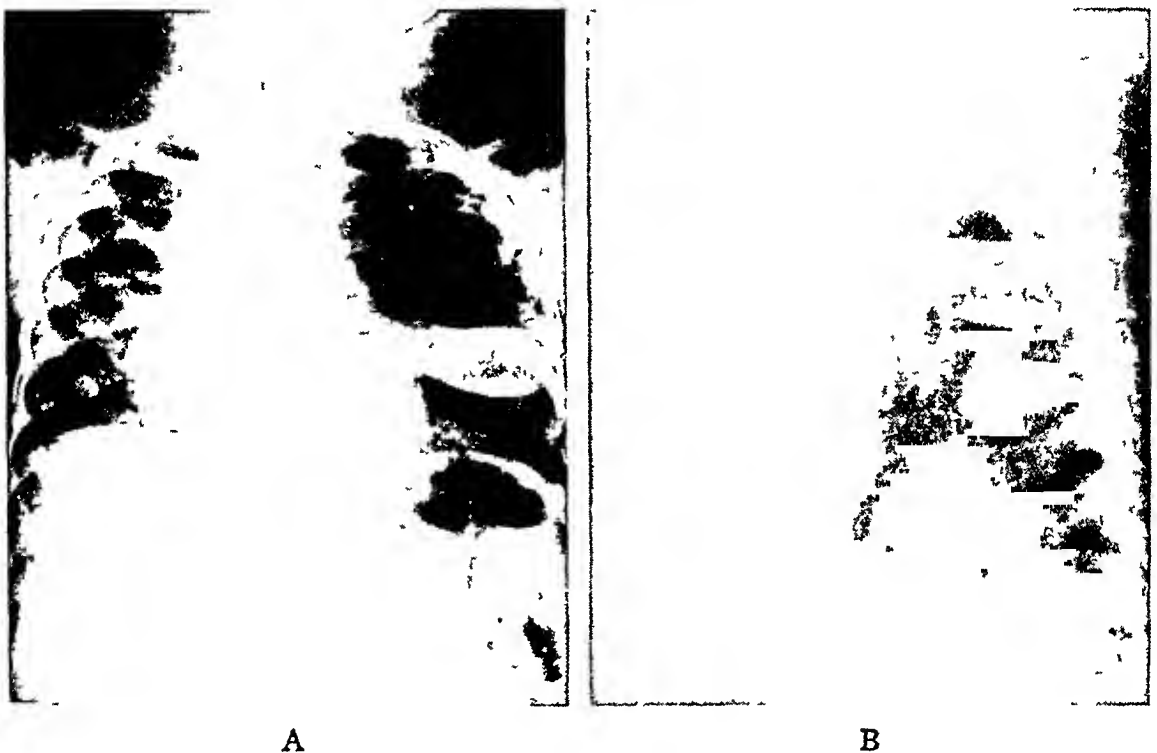


FIG 13—Case 8. A. Roentgenogram taken after aspiration of cyst contents and replacement with air and small amount of lipiodol.
B. Lateral view of the same.

mediastinal region. The patient never had any symptoms referable to the thorax. Physical examination was essentially negative. Roentgenogram of the chest showed a rounded density projecting from the left side of the mediastinum slightly above the hilar region. The mass was of homogeneous density and the margins were smooth (Fig 11A). A lateral film showed that the mass was located in the anterior mediastinum (Fig 11B). Preoperative diagnosis was dermoid cyst.

Operation—A large, rounded, relatively thin-walled cyst occupied the upper anterior aspect of the left pleural space, projecting into it from the mediastinum. The wall of the cyst contained cartilaginous plaques. The attachment of the cyst was near the anterior aspect of the hilum of the left lung in close association with the left main bronchus but not actually attached to the bronchus. Anterior to the attachment of the cyst in the mediastinum there was a congenital defect in the pericardium measuring approximately three centimeters in diameter. This defect was just posterior to the pericardiophrenic vessels and phrenic nerve. Through the defect in the pericardium the main pulmonary artery and the tip of the auricle could be seen. No inflammatory adhesions were present. No other anomalies were noted. The bronchiogenic cyst was excised intact. The defect

in the pericardium was partly closed with the flap of mediastinal pleura which had been dissected from the cyst. The postoperative course was uneventful. There was no accumulation of fluid in the pericardial sac postoperatively, as determined by roentgenograms.

Cut section of the excised cyst revealed a relatively thin-walled sac filled with brownish, thick, mucilaginous material. Several trabeculae were present within the cyst.



FIG 14—Case 8. Roentgenogram after surgical removal of the bronchiogenic cyst. Note well expanded left lung.

Microscopic examination revealed a lining of ciliated columnar epithelium. The underlying stroma contained mucous glands, fragments of cartilage, bundles of smooth muscle and islands of lymphoid tissue.

Case 8—J. J., female, age nine months. This baby was admitted to Kings County Hospital because of dyspnea and bouts of cyanosis since birth and frequent respiratory infections. A diagnosis of unresolved pneumonia of the left upper lobe had been made. Chest roentgenogram, however, revealed a shadow suggesting a large cyst (Fig 12). A

needle was introduced into this region and thick, gelatinous, yellow material, which was sterile on culture, was aspirated. At a second aspiration of the cyst some air and a small amount of lipiodol were introduced and further roentgen-rays taken (Fig 13A and 13B). A diagnosis of bronchiogenic cyst was made.

Operation—A large, thin-walled cyst which was attached by a small pedicle to the mediastinum near the anterior end of the interlobar fissure close to the phrenic nerve was found. A structure like a small bronchus could be felt in the mediastinal pedicle of this cyst, but this ended blindly and was not in close association with the remainder of the tracheobronchial tree. The cyst was excised and the postoperative course was uneventful. Microscopic examination revealed the characteristic findings of a bronchiogenic cyst. The lung expanded well after operation (Fig 14).

SUMMARY

Bronchiogenic cysts of the mediastinum result from the faulty development of elements of the primitive foregut. The cyst wall resembles that of the bronchus. The symptomatology depends chiefly on the size and location of the cyst. The various clinical pictures associated with the lesion are discussed in relation to the site of the cyst. Bronchiogenic cysts are a common type of mediastinal tumor. Surgical excision is usually indicated, although a considerable percentage of the patients are asymptomatic when the lesion is first discovered on a roentgenogram. Eight illustrative cases are reported.

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MID-LEG AMPUTATIONS FOR GANGRENE IN THE DIABETIC

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DIABETES appears to be a progressive disease, in spite of the apparently satisfactory control of the carbohydrate metabolism by insulin. Banting's brilliant discovery opened a new era in the treatment of diabetes, and patients with this disease were led to believe that they could look forward to a normal, healthy adult life if they continued to observe care in diet and insulin administration. Among the profession at large an attitude of complacency has developed, and it is widely assumed that the diabetic is well controlled when the blood sugar level is approximately normal and there is no glycosuria. Students of this disease, however, are agreed that control of the carbohydrate metabolism can prevent coma and relieve symptoms, but that the more profound disturbances resulting from diabetes are not corrected by the use of insulin, and that progressive deterioration of the vascular system of the entire body takes place, resulting in albuminuria, hypertension, retinal changes, cardiac and peripheral vascular disease.

As a surgeon familiar with the frequent necessity for amputation in the pre-insulin days, I anticipated that the universal use of insulin would be reflected in a gradual decrease in the incidence of gangrene and amputations in patients with diabetes. It is an outstanding fact that such has not been the case, and it is unhappily accurate to state that because of insulin, many more diabetics live long enough to require amputations of one or both legs. Furthermore, by the time a diabetic has reached the point where he requires amputation of a leg for gangrene, his life has nearly run its course, and he will be among the select few if he is alive five years later. If alive, it is probable that loss of the second leg will have been necessary.

Contributing to the present unsatisfactory picture of diabetes is the high mortality which results from thigh amputations for gangrene. With very few exceptions, the prevailing death rate ranges from 25 per cent to 50 per cent. Table I presents the reported mortality for this procedure in a group of metropolitan hospitals. There were 547 deaths, or 44 per cent, in 1,242 cases of mid-thigh amputations in diabetics. Excluded from this table are the statistics of the Deaconess Hospital in Boston, because of the unique record of this institution. Joslin states that "major amputations numbering 767 between 1932 through 1942, showed a mortality of 12.3 per cent."¹⁸ This unusually low mortality may be due to special factors such as inclusion of many patients of the affluent class, and to the practice of amputation for very early lesions of the extremities. It is apparent that such a low mortality is not characteristic of the country at large, particularly in the large municipal hospitals.

Since the technical procedure of a thigh amputation is simple and requires

no great skill, the prevailing high mortality indicates that this procedure is too severe for the average patient with diabetes. It is readily apparent why this is so. The patient with diabetic gangrene is usually a poor operative risk. He is past middle age, and often has complicating arteriosclerotic cardiorenal or cerebrovascular disease. His vitality may have been reduced by prolonged suffering and by absorption of toxic products from his gangrenous or infected

TABLE I—*Mortality Following Thigh Amputations for Gangrene in the Diabetic*

	Cases	Deaths	Period	Per Cent Mortality
Montefiore (1)	17	10	1932—1936	59
Mount Sinai (1)	68	26	1926—1936	38
Morrisania (2)	45	27	1931—1935	60
Bellevue, 1st division (a)	40	21	1931—1935	52
Bellevue, 2nd division (a)	35	22	1931—1935	63
Bellevue, 3rd division (a)	70	26	1931—1935	37
Bellevue, 4th division (a)	24	18	1931—1935	75
Lenox Hill (3)	13	5	1935—1939	38
St Luke's (4)	25	9	1934—1938	36
New York (5)	31	9	1932—1940	29
Roosevelt (6)	12	3	1935—1939	25
Mary Immaculate (Jamaica) (7)	24	12	1930—1935	50
Israel Zion (8)	99	32	1934—1943	32
Kings County (9)	73	34	1936—1941	46
Massachusetts General (10)	36	12	1916—1926	33
Philadelphia General (11)	130	73	1926—1933	56
Philadelphia General (12)	127	61	1937—1939	48
Philadelphia Episcopal (13)	56	27	1926—1935	48
New Orleans Charity (14)	114 (b)	48	1929—1937	42
Indianapolis City (15)	78 (c)	31	1930—1938	40
Rochester University (16)	106 (c)	34	(Not stated)	32
Nebraska University (17)	19	7	1932—1942	37
Total	1242	547		44

a Reported at N. Y. Academy of Medicine May 11, 1937
b Diabetic and non diabetic arteriosclerosis
c Thigh and leg amputations combined

foot. To relieve pain he has received considerable quantities of narcotic drugs. It has been difficult to control the carbohydrate metabolism properly because of the diminished effectiveness of insulin in the presence of infection and gangrene. Such a patient should be subjected to as little operative trauma as possible. The operative procedure should be brief, profound anesthesia should be avoided, and amputation should be carried out as far distally as possible.

It has been taught for many years that amputations should be done through the thigh in order to insure adequate circulation for healing. This widespread belief has been proven incorrect by numerous surgeons in the past few years. McKittrick,^{19, 20} Beverly Smith,²¹ Maes,²² Crossan,¹³ Bickel,²³ and others, have advocated amputations below the knee, and have reported good

results following this procedure. My own experience, likewise, indicates that amputations can be performed safely below the knee in diabetic patients, even when the popliteal artery is closed and oscillometric readings indicate a seriously deficient circulation.

CLINICAL MATERIAL

The present series consists of 127 instances of extensive gangrene with or without infection in diabetic patients treated by mid-leg amputation during the years from 1940 to 1946. Fifty-eight of these patients were ward cases at the Montefiore Hospital, and the other 69 were seen in private practice. In addition, 24 non-diabetic patients with arteriosclerotic gangrene have been similarly treated, making a total of 151 amputations. Advanced impairment of circulation was present in all cases. In most of them the popliteal pulse was absent and in some even the femoral pulse could not be felt. Only rarely during this period was a thigh amputation done in a patient with diabetes, and only for exceptional reasons, such as marked contracture of the knee joint or unusually poor condition of the tissues of the leg. The majority of the operations were done by the writer but many were done by colleagues or house staff surgeons under his supervision. It is important to point out that patients admitted to the wards of Montefiore Hospital are frequently in rather poor condition due to age, poor economic status, and prolonged chronic illness. Many of them have passed through other hospitals, and are transferred to Montefiore as chronic invalids. In general, it may be stated that in New York, recommendations for amputations are not readily accepted by most patients, and usually consent is finally obtained only when extensive gangrene and infection have developed. This is a factor which has a considerable bearing on mortality figures. An attempt has been made to grade the general condition of each patient depending upon age, toxicity, cardiac status, presence of hypertension, and degree of peripheral vascular involvement. Table II summarizes this information, and contrasts the mortality in the different groups.

TABLE II—*Mortality in Diabetic Gangrene Depending Upon General Condition of Patients**

Group	Condition	Number of Patients	Operative Deaths	Mortality Per Cent
A	Good	8	0	0
B	Fair	34	1	3
C	Poor	50	5	10
D	Precarious	35	6	17
Totals		127	12	9.4

* Division of diabetic patients into groups based upon age, toxicity, cardiac status, hypertension and degree of peripheral vascular impairment.

TECHNIC OF OPERATION

The patient is placed on the table face down, as this position permits flexion of the leg, and makes the operation much easier. Spinal anesthesia, using less than 100 mg of novocaine, or light general anesthesia is employed. A tourniquet is not used. A circular incision is made through the skin and fascia at a level 8 inches below the patella. Flaps of any kind are avoided. The muscles are divided at the level of the retracted skin. As soon as the superficial layer of calf muscles is sectioned the posterior tibial vessels and nerve are exposed, lying on the deep layer of muscles. The vessels and nerve are ligated and divided and the nerve is injected with alcohol. The leg is then flexed and the anterior tibial group of muscles is sectioned, exposing the anterior tibial vessels and nerve near the interosseous membrane. These structures are then ligated and cut, thus controlling the major sources of bleeding. The leg is again placed horizontal and the deep layer of muscles on the posterior surface is sectioned. The muscles are then separated for a few inches from the bones and the bones are sawed through, the tibia about one inch and the fibula about two inches above the level of the skin incision. Periosteum and bone are cut at the same level. The anterior edge of the tibia is then beveled by an oblique saw cut. Any muscle that has been damaged during the procedure is trimmed away, and careful hemostasis obtained. The wound is thoroughly irrigated with sterile water. The wound is left wide open and is dressed with a combination of paraffin mesh and vaseline gauze. A posterior molded plaster splint is applied and the dressing is not changed for a week. Thereafter the wound is dressed with cod liver oil ointment and the dressing is changed every third day until the stump is healed. There is frequently considerable secretion from the wide open wound and usually some superficial slough of damaged tissue for the first two or three weeks. Then the wound gradually becomes a clean, granulating surface in the center of a rapidly contracting scar. Infections of the stump or other complications are rare. The postoperative course is usually smooth and painless.

It is important to continue the use of the posterior molded splint until the wound is well on the way to healing. Contracture at the knee takes place readily unless a splint is used, and such a contracture is difficult to overcome. In the first few cases a tourniquet was used around the thigh to expedite the operative procedure. Three patients developed gangrene of the leg stump and required secondary thigh amputations. The use of a tourniquet was therefore abandoned. Since then more than 120 consecutive cases have had mid-leg guillotine amputations without the use of a tourniquet, and in only three of these has a higher amputation been necessary. Healing in all patients has been surprisingly good. In a few, minimal necrosis of the skin margin has developed, but this has not interfered with a satisfactory end result.

The process of healing presents some surprises. As soon as a rim of scar tissue forms at the periphery of the wound, contraction of the scar tissue begins and gradually pulls the skin down over the end of the stump (Fig 1 and 2). This process continues until healing is complete, and the final scar is



FIG 1—Early stage of healing Note skin drawn over end of stump by contracting scar tissue

— — —



FIG 2—Later stage of healing Small granulating wound in center of contracting scar

frequently so small that it can be covered with a 25 cent silver coin (Fig 3 and 4) *It is not necessary to apply any form of traction to the stump to accomplish this result* The pull of the contracting scar tissue is sufficient Complete healing usually requires from 10 to 12 weeks Patients are allowed out of bed the day after operation in most cases, and can leave the hospital on crutches four to six weeks after operation

RESULTS



FIG 3—Well-healed stump Note relatively small area of scar to circumference of stump

Every death which occurred before the stump was healed is regarded as an operative mortality, even though the cause of death was entirely unrelated to the surgical procedure In the entire group of 127 diabetic patients there were 12 deaths a mortality of 9.4 per cent In the ward group of 58 patients there were 7 deaths (12.1 per cent), in the private group of 69 patients there were 5 deaths (7.2 per cent) The significance of these figures is clear It is not necessary to have a high mortality in amputations for gangrene in the diabetic When the severity of the operation is reduced to the limited endurance of the patient this mortality can be reduced to less than 10 per cent

The non-diabetic group of arteriosclerotic gangrene is similar in age and general condition to the diabetic group, and for the sake of completeness may be included with the latter In this group of 24 cases there were 2 deaths Thus, in the total number of 151 patients treated by mid-leg amputation, there were 14 deaths, a mortality of 9.3 per cent

Certain other advantages of the low amputation should be stressed The use of an artificial limb is greatly facilitated if the patient retains his knee joint and about six inches of his leg (Fig 5) Such patients are frequently able to walk without the use of a cane or crutches, and with scarcely any perceptible limp On the contrary, when amputations are done through the thigh, experience has shown that almost none of the women and only about half of the men ever accustom themselves to the use of an artificial leg Many of the 151 patients in the present series, including one man and one woman over 80 years of age, have been fitted with and are wearing artificial legs I know of no instance where a well healed stump has broken down and required further surgery

It is worth recording that none of the below-knee stumps have been per-

AMPUTATIONS FOR GANGRENE IN THE DIABETIC

sistently painful. Pain in *thigh* stumps is common, and is one of the most distressing complications of amputations of the lower extremities. It is frequently not relieved by injections of reoperations on the sciatic nerve or sympathetic nervous system, and chordotomy and excision of parts of the cerebral cortex have been employed in an effort to control it. I do not know why leg stumps are painless, but this is one of the great advantages of the low amputation.

Are there any contra-indications to the mid-leg amputation? In my opinion there is only one group of cases that is not suitable for this procedure. These are the patients who have had a recent thrombosis of the

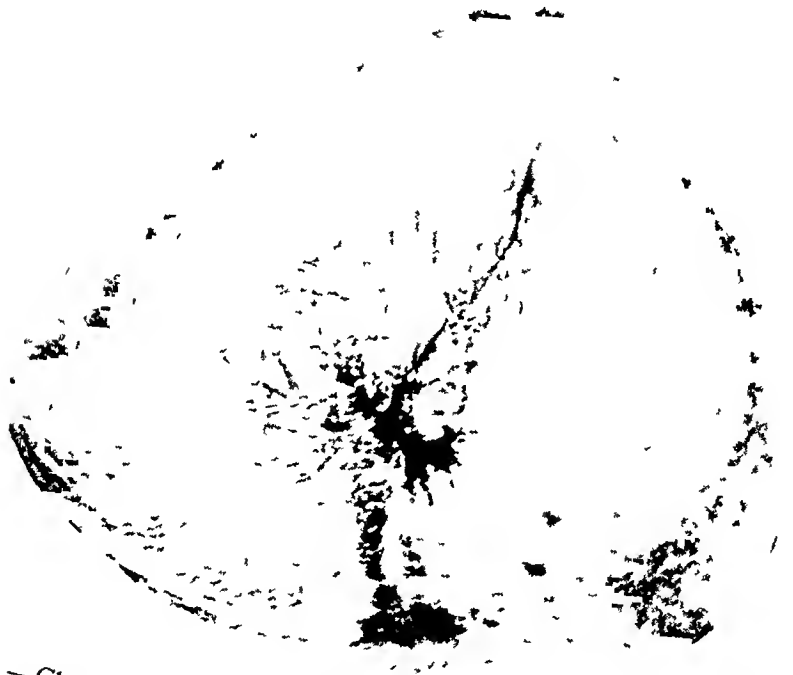


FIG 4—Characteristic small scar at end of well-healed stump

femoral artery, and gangrene develops within a few weeks of onset. Such cases are readily identified, as they give a history of abrupt onset of pain without preceding intermittent claudication. Unless there has been an interval of at least 3 months after the arterial occlusion, there has not been time for an adequate collateral circulation to develop to the mid leg, and it is not safe to amputate below the knee. It has been my experience that such cases are relatively few.

PRIMARY CLOSURE OF MID LEG AMPUTATION

In the first 100 diabetic cases treated by guillotine amputation without any attempt at closure, there were 8 deaths (8 per cent). Having obtained this basic mortality figure, some cases were selected in the second hundred for



FIG 5—Well-healed stump after guillotine amputation. Preservation of knee joint and upper part of leg improves ability to walk with artificial leg.

primary closure following amputation at this level. With this modification healing is complete in 2 to 3 weeks. There are three dangers in primary closure: infection, tension on tissues causing impairment of circulation, and inadequate circulation at the operative level causing localized necrosis of tissue. In cases treated by primary closure an attempt to prevent infection was made by treating each case for one week before and one week after operation with injections of penicillin. Care was used to avoid tension on the suture line and few sutures were used. In 6 selected cases in the diabetic group treated in this manner, 4 healed by primary union, and 2 had a narrow area of gangrene along the suture line which delayed healing but did not prevent an ultimately satisfactory result. In addition, 3 cases in the non-diabetic group, closed in the same way, healed by primary union.

While the results in this small group of 9 cases has been all that could be expected, it is still a question whether it is desirable to take the additional risk of primary closure to save a few weeks of healing time. Most of the diabetic patients who require amputation are beyond 60 years of age and are no longer engaged in active work. The granulating wound resulting from a guillotine amputation left entirely open is not painful and does not require hospitalization. Visits on crutches to the surgeon's office twice a week are sufficient for dressing the stump. The advisability of primary closure will depend on further experience with this modification.

NECESSITY FOR AMPUTATION OF SECOND LEG

The number of patients with diabetes who require amputation of the second leg has not been determined in a large series of patients. The American Diabetes Association has no data on this point. Joslin¹⁸ stated that of 100 patients, 39 subsequently required amputation of the second leg. In the present series of 127 patients, 20 required amputation of the second leg during the known period of observation, and the follow-up is incomplete. When patients who have been followed for only a short period are excluded, more significant figures are obtained. For example, among the diabetic patients

seen in my private practice, there are 49 with one amputation who have been followed for over 3 years. Among these, 21 or 43 per cent, have required amputation of the second leg. This figure closely approximates that of Joslin cited above. Thus it appears that about 40 per cent of diabetic patients who survive 3 years after the loss of one leg will require amputation of the second leg. More extensive data on this point are desirable, and a significant reduction in the percentage of patients who required amputation of the second leg could be accepted as evidence of the value of the prophylactic treatment used in the interval. Ligation of the femoral vein of the second leg is being done at the time of primary amputation in a series of cases at the Montefiore Hospital to determine if this procedure has any merit as a prophylactic measure. It will take many years to determine this point. Sympathectomy might also be tested in this manner.

DURATION OF LIFE AFTER AMPUTATION OF LEG

It has been stated that the average expectancy of patients with diabetes after amputation of one leg is about 3 to 4 years.²⁴ Experience with the present series of cases confirms the above statement. Thirty-five (27 per cent) of the 127 cases in this series are known to be dead within 3 years after amputation, and since the follow-up is incomplete, the real figure may well be twice as high. Twenty-four patients of this series are alive and comparatively comfortable 3 to 5 years after amputation. Forty-nine of a series of 117 diabetic patients with amputations seen in my private practice have survived 3 years or more since operation (41 per cent). Thus it appears that only about 40 per cent of diabetic patients will live more than 3 years after amputation of a leg.

SUMMARY AND CONCLUSIONS

Although the discovery and use of insulin has made the diabetic patient more comfortable and has prevented diabetic coma, the more profound disturbances are not corrected and diabetes remains a progressive, degenerative disease.

Amputations for gangrene in the diabetic are more frequent than in pre-insulin days.

Routine mid-thigh amputations result in a high operative mortality, unnecessary loss of function, and many painful amputation stumps.

Mid-leg amputations are advocated because of low operative mortality, preservation of better function, and freedom from stump pain. In 127 diabetic patients subjected to mid-leg amputation there were 12 deaths, a mortality of 9.4 per cent.

Only about 40 per cent of diabetic patients will survive longer than 3 years after amputation of a leg. Of those who survive about 40 per cent will require amputation of the second leg.

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JUVENILE NASOPHARYNGEAL ANGIOFIBROMA

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JUVENILE NASOPHARYNGEAL ANGIOFIBROMA, though neither a common nor a malignant neoplasm, nevertheless presents serious problems because of the complications which are invariably associated with its growth and its treatment. This tumor, moreover, is of considerable scientific interest in that it is one of the few neoplasms which exhibit a marked sex predilection—etiologically related in this case, we believe, to a sex-endocrine imbalance. The present report is based on an analysis of 29 cases of juvenile nasopharyngeal fibroma observed on the Head and Neck Service at the Memorial Hospital from 1927 to 1946, inclusive.

DEFINITION

Juvenile nasopharyngeal angiofibroma is a specific, highly vascular, non-infiltrating, essentially benign neoplasm, occurring in the nasopharynx or posterior nasal cavity of pubescent males. Symptomatically the tumor is characterized by nasal obstruction, repeated epistaxis, and by progressive growth throughout the period of adolescence, with a tendency toward spontaneous regression at about the time of sexual maturity.

While the term *juvenile nasopharyngeal angiofibroma* is anatomically specific and descriptive for the tumor, it is somewhat cumbersome, and for the sake of convenience in the remainder of this report, it will often be shortened to *nasopharyngeal fibroma*. Other terms which have been employed elsewhere to designate this neoplasm include *myxofibroma*, *juvenile basal fibroma*, *nasopharyngeal fibroma of adolescence*, *fibroids of the nasopharynx*, and *bleeding fibromas of adolescence* †.

* Dr. Jules Abels died June 13, 1947.

† *Historical Note*—The earliest Greek, Roman, and Arabian medical writers used the term *nasal polyps* (Zool—many footed) to designate all tumors or swellings within the nasal cavities or nasopharynx which caused obstruction to breathing.¹³ Subsequent medical writers employed the same term for several hundred years. As time passed, more than one variety of nasal polyps were recognized and by the 18th Century such lesions were often differentiated as soft or mucous and hard or fibrous nasal polyps, finally, they were classified into three groups—(1) soft (2) fibrous and (3) malignant. It is somewhat difficult to ascertain just when a specific form of nasopharyngeal fibroma of adolescence was first recognized, but as early as 1847 Chelius⁴ stated that fibrous nasal polyps "commonly occur in persons about the time of puberty."

ETIOLOGY

Nasopharyngeal fibroma is not a common tumor. In the Head and Neck Clinic of the Memorial Hospital about 2,000 new cases of neoplasms in the tissues of the head and neck are admitted annually, and of these there are usually one or two cases of nasopharyngeal fibroma. In the literature, most of the case reports number from one to three. A few fairly large series have been published, namely those of New and Figg^{21, 9} from the Mayo Clinic — 63 cases, and of Shaheen⁶ — 58 cases. Some aspects of the clinical material in these two reports, especially with regard to the ages of the patients and the fairly large proportion of females, suggest to us, for reasons to be considered later, that the cases have not been critically selected and that not all are actually juvenile nasopharyngeal fibromas as defined in the present report.

Age Incidence — In our series of 29 cases, the age at the onset of symptoms varied from 7 to 19 years with an average age of 14 years. The age on admission averaged about 1½ to 2 years later—that is about 16 years, which is a little younger than Figg's⁹ figure of 18½ years at the time of the first examination. In one of our cases, the patient was admitted at the age of 36 years, but had symptoms since the age of 16.

The onset of nasopharyngeal fibroma always occurs during adolescence and is one of its most characteristic clinical features. While many observers,

Considerable space is given in the surgical texts of the early 19th Century to operations for the removal of bulky nasal polyps, especially when the tumors became so large as to produce what was known as a "frog face" deformity. Nevertheless, surgeons of that period, and some even up to the year 1900, appear to have been unaware of any age or sex predilection for these "fibrous nasal polyps." Legouest¹⁷ in 1865 was one of the earliest to call attention to the selectivity of these tumors for males. Gosselin¹¹ in 1876 noted a tendency toward spontaneous regression after sexual maturity. The first comprehensive study of nasopharyngeal fibroma is to be found in a review on the general subject of nasal polyps in 1878 by Bensch,² who collected the scattered case reports and made an excellent morphologic and clinical description of this neoplasm. Chaveau³ in 1906 suggested the term *juvenile nasopharyngeal fibroma*.

The first attempts at surgical removal of these tumors were made as early as the time of Celsus, by digital manipulations or by tearing off the tumor masses with forceps or snares. Later, injections of various escharotics and the actual cautery were employed.

About the middle of the 19th Century, several operative technics were devised to gain better access to the nasal cavities and the nasopharynx. Langenbeck¹⁰ proposed an anterior approach through the skin of the cheek leaving the bone attached to the osteoplastic flap and temporarily resecting the maxilla. After removal of the tumor, the flap with the attached bone was replaced and the wound was sutured. To obtain access to the nasopharynx, Rouge²⁵ reflected the nose upward and resected part of the septum by an incision in the upper gingivo-buccal gutter. Ollier²² made a V-shaped incision with its base opposite the nasal ala, reflecting the whole nose downward. All of these operations were rather bloody and the mortality was high. Bilateral ligation of the external carotid arteries and tracheostomy were mentioned as preliminary surgical measures as early as the 1880's.

Most of the reports in the literature consist of three or less cases and the clinical data are often meagre and uncertain. In recent years several larger series have been published which we shall discuss later in greater detail.

as far back as Chelius⁴ in 1847, have believed that this neoplasm occurs mainly in children, hence the eponym "juvenile," nevertheless such observers as New and Figi^{21, 9} and Shaheen²⁶ have included cases with a supposed onset long after sexual maturity. Some of these apparent variations may arise by recording the age of the patient on admission rather than the age at the onset of symptoms. Shaheen²⁶ is the only recent observer who has reported the occurrence of this tumor during infancy and old age (2 and 4 years, 67 and 70 years, respectively). Since Shaheen appears to be unaware that his reports of cases occurring at the age extremes are at variance with those of most other observers and since he offers no histologic or other corroborant data, we feel that these particular cases are not all acceptable as genuine instances of juvenile nasopharyngeal fibroma.

The duration of the tumor before it produces symptoms cannot of course be determined. From the observed rate of growth following the first examination in untreated patients, however, it is probable that a silent period of 2 to 3 years may elapse, bringing the onset of the tumor to between 11 and 12 years. We have not been able to find any comment on this probability in other reports.

Sex Relationship—In the course of the present study, certain sex-endocrine factors of probable etiologic significance became apparent. These were

- 1 The disorder was limited to young males.*
- 2 These patients in most instances gave the clinical impression of undersexual development, both physically and emotionally.
- 3 In spite of roentgen-ray therapy the tumor significantly regressed only after secondary sex characteristics were developed fully, there was one exception in the 29 cases presented.
- 4 In two instances in which puberty was hastened by the administration of androgens, roentgen-radiation appeared to induce a more ready regression of the tumor.

* All of our 29 patients with nasopharyngeal fibroma were males and we are of the opinion that this neoplasm never occurs in females. Beginning with Legouest¹⁷ in 1865, many subsequent authors have recognized that the incidence of this tumor was considerably greater in males, but we are the first, so far as we know, to advance the proposition that juvenile nasopharyngeal fibroma is a completely sex-bound neoplasm. We realize that this point of view may not be generally accepted without question at this time, for all previous authors who have reported large series have given a definite percentage of female incidence (Figi and New, 7 per cent, Shaheen, 8 per cent). At the Memorial Hospital, up until about 10 years ago, we also believed that juvenile nasopharyngeal fibroma occurred occasionally in females, but since that time we have subjected all cases so diagnosed in female children to careful scrutiny. These investigations, based not only on biopsy but also on the subsequent clinical course, have failed to support the diagnosis of nasopharyngeal fibroma in a single female patient in our clinic. In three suspected cases in females the lesions on biopsy proved to be simple choanal polyps. In two other cases the eventual diagnosis was tuberculosis of a retropharyngeal lymph node and chondroma arising in a superior nasal turbinate, respectively. In none of these tentatively diagnosed cases of juvenile nasopharyngeal fibroma in females were found the characteristic symptoms and clinical course—progressive nasal obstruction, recurrent epistaxis, and spontaneous regression at sexual maturity.

These observations strongly suggest that juvenile nasopharyngeal fibromas may result from a deficiency of androgen activity or, perhaps, from an overproduction of estrogens. Unfortunately, little or no information is available concerning estrogen production by pubescent males from which conclusions might be drawn.

There is, however, considerable clinical and experimental evidence that vascular tissue can be influenced by certain of the sex hormones, but these effects are not always uniform. In cutaneous areas characterized by a large venous bed, the capillaries of *castrated* males are found widely dilated and this dilatation can be reversed by the administration of testosterone propionate.⁷ Likewise, the excitability of cutaneous blood vessels has been found to be more extensive in castrated men and this excitability to graded mechanical stimuli could be increased by estradiol and decreased by testosterone propionate.²⁴

The observations of Soskin and Bernheimer²⁷ that relief of atrophic rhinitis was obtained by estrogen administration stimulated several studies concerning the relation of sex hormones to mucous membrane hyperemia. Of these, the work of Reynolds and his co-workers²³ bears most on the present clinical study. These investigators demonstrated that hyperemia of the mucous membranes was a function of blood estrogen content and could be induced by further estrogen administration. Furthermore, the mechanism of the hormone action was discovered to be due probably to the local production of acetylcholine. The clinical and experimental value of these observations have been demonstrated in the treatment of peripheral vascular disease. For example, gangrene induced by ergot drugs can be prevented by estrogen administration.¹⁸

During the course of further studies it is planned to give much more consideration to the sex linked character of this tumor. Particular attention will be given to

- 1 The determination of "developmental age" of these patients by roentgen-ray examination of ossification centers

- 2 The excretion of total 17-ketosteroids, for this a considerable amount of work first must be done to establish the normal range for the 17-ketosteroid excretion of the pubescent male

- 3 The effects of androgens alone in massive doses on the tumor before roentgen-radiation or surgery is applied

- 4 The effects of estrogens on the appearance of the tumor

Histogenesis—Histologic study in our cases reveals that in the tumors of younger subjects the angiomatous elements predominate and occasionally a microscopic picture of fully developed cavernous angioma is noted. It is probable, therefore, that in the beginning these growths are principally angiomatous rather than fibromatous. If estrogenic stimulation is a factor in the etiology of these tumors, their histogenesis can be reasonably explained as an overgrowth of vascular tissue in the nasopharynx, a result of an abnormal

stimulus to the local circulation. The fibromatous elements, at first being only supporting stroma of the tumor, develop as a structural component and become predominant as the estrogenic effect is lessened. An identical phenomenon is the gradual replacement of the angiomatous elements by fibrous tissue as seen in ordinary hemangiomas following spontaneous or therapeutically induced sclerosis of the blood vessels.

When the patient approaches sexual maturity, as will be later described, all tumors tend to become less vascular and often completely fibrous, which suggests that as the abnormal stimulus disappears the proliferation of blood vessels also ceases. This hypothesis, if correct, is sufficient to explain the histogenesis of this tumor.

Other genetic theories have been advanced which presuppose that the growth is of fibroblastic origin. The most prevalent and hitherto accepted explanation of the origin of nasopharyngeal fibroma, first advocated by Verneuil²⁹ and supported by Bensch,² Ewing,⁸ and others, is that the growth is derived from embryologic fibrocartilage during development of the skull. The embryonal occipital plate, a cartilaginous structure, gives rise to the basilar portion of the occipital bone, body of the sphenoid bone, medial pterygoid process, and bones in the region of the foramen lacerum and pterygopalatine space. Until early adult life the basilar portion of the occipital bone is joined to the body of the sphenoid bone by the remaining portion of embryonal cartilage. This cartilaginous plate becomes ossified by the 25th year. According to these authorities, perichondrium (fibrous connective tissue) covers the cartilaginous plate and from this or other perichondrium of the postnasal space juvenile nasopharyngeal fibroma is supposed to develop. This hypothesis is attractive in that it accounts for the phenomenon of spontaneous regression of the tumor about or after the 25th year, and also, for its various anatomic sites of origin. The latter theory, however, does not explain the sexual selectivity of this tumor nor does it take into consideration the presence of angiomatous elements which are integral and, perhaps, the more significant morphologic components of nasopharyngeal fibroma.

In 1943 a case of chondrosarcoma of the nasopharynx occurring in an adolescent boy was reported by Wirth.²⁸ Although this tumor finally metastasized to the lungs as chondrosarcoma, the initial biopsy was compatible with a diagnosis of juvenile nasopharyngeal angiofibroma. The presence of cartilage even in the first biopsy specimen, the lack of response of the growth to large doses of external and interstitial radiation, and subsequent biopsy reports (vascular embryonal chondroma, chondrosarcoma) mitigate against this growth being a genuine nasopharyngeal fibroma in the beginning, as Wirth admits. If it could be proved, however, that chondrosarcomatous transformation can occur in a pre-existing nasopharyngeal fibroma, it would favor the prechordal plate genetic theory of Verneuil.

Other Causative Factors—Further analysis of our data reveals no evidence of any systemic disturbances. The majority of patients were investi-

gated for syphilis, tuberculosis, and other infections and were found to be free from these diseases. Allergy or trauma did not appear to be etiologic factors. Congenital anomalies, mal-developments and other associated tumors were not encountered and in no case were either neurofibromatosis or hemangiomatous tendencies present. The boys were not retarded, either physically or mentally, and except for evidence of underdevelopment of secondary sex characteristics in over one-half of the cases, they appeared normal in all other respects.

No tendency toward racial or familial predilection was noted in the present series or in any previously reported cases.



FIG 1—Surgical Specimen of Nasopharyngeal Fibroma. This bulky, lobulated, cartilaginous-like mass was removed from the nasopharynx and posterior nasal cavity of an 11-year-old boy by a radical Weber-Ferguson type of resection of the maxilla. Note that the tumor is dumb-bell shaped, one portion projected into the posterior nasal cavity and the other beneath the soft parts of the cheek in the infrazygomatic and temporal areas.

PATHOLOGY

Gross Pathologic Anatomy—Nasopharyngeal fibroma is an unencapsulated fungating, vascular tumor. The surface of the growth, if not traumatized by operative intervention or packing to control hemorrhage, is covered by intact mucous membrane, highly injected and deep red in color in younger subjects and pale pink in older patients or those in whom the vascularity has been reduced by radiation or sex hormone therapy. If there has been hemorrhage with the attendant trauma of packing, ulceration and necrosis occur and the surface of the tumor may become granular.

In our cases, with one exception, the growth ranged from 2 to 5 cm in

greatest diameter and the average size was 3 cm. One tumor was so large (10 cm) as to be out of proportion to the standard variation in this series.

In the specimens available for gross morphologic study, unusual variations and combinations were noted. Although the shapes of the tumors differed widely, the commonest types were ovoid or club-shaped. The surface was either smooth or definitely lobulated (Fig 1). Some of the tumors were rubbery or cartilaginous in consistency while others were soft, edematous and occasionally friable. On section the color of the neoplasms ranged from pinkish white to grayish yellow to reddish brown, and translucent tissue was seen as often as homogeneous tissue. All growths were solid with no areas of

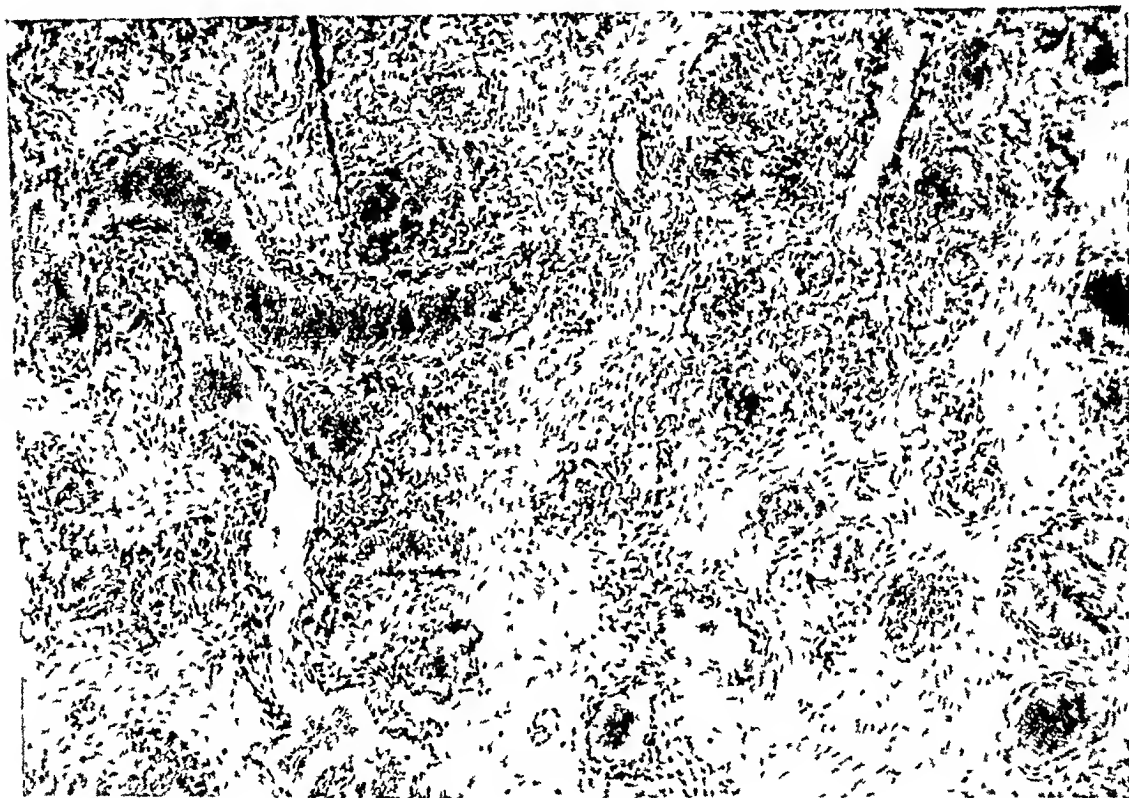


FIG 2—Vascular Phase of Nasopharyngeal Fibroma. In this microphotograph of an extremely vascular nasopharyngeal fibroma in a 10-year-old boy, the microscopic appearance is that of a fully developed cavernous angioma in a fibrous stroma. Some of the blood vessels have become sinusoid. This tumor had no previous sex hormone or radiation therapy.

cystic degeneration. Older tumors or those which had been subjected to radiation therapy were usually densely fibrous and pale, younger and untreated tumors were soft and deeply vascular.

Histopathology—Nasopharyngeal fibroma is composed essentially of connective tissue and blood vessels. In microscopic appearance it may vary from that of a fully developed cavernous angioma in a fibrous stroma (Fig 2) to that of a densely cellular or occasionally myxomatous fibroma (Fig 3). The usual histologic pattern consists of connective tissue stroma containing numerous spindle-shaped immature fibroblasts and thin-walled blood vessels in

varying proportions. In fact, spindle- and star-shaped fibroblasts may be so numerous as to suggest fibrosarcoma or angiosarcoma, with which juvenile nasopharyngeal angiofibroma is often confused. In younger subjects and in untreated tumors, the angiomatous elements are in abundance, the vessels becoming large, irregular and even sinusoid, in older tumors or in those which have been subjected to radiation therapy or intensive treatment with androgens, the vascular components are less prominent or they may disappear altogether and fibrous elements predominate. Foci of lymphocytes and plasma cells may be present, especially in those tumors which are ulcerated or traumatized. Myxomatous changes in varying proportions are frequently found,

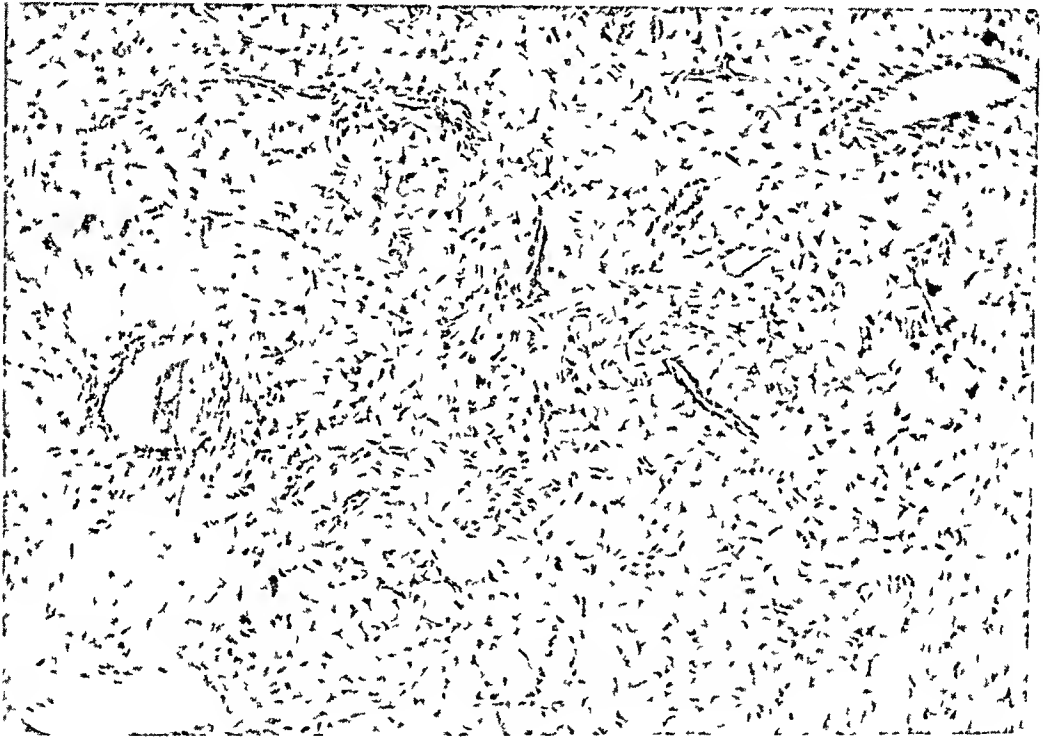


FIG 3—Avascular Phase of Nasopharyngeal Fibroma. The microscopic appearance of a relatively avascular nasopharyngeal fibroma consists of sparsely scattered blood vessels in a densely cellular stroma. This histologic pattern of replacement of angiomatous elements by connective tissue (involution) can frequently be brought about by androgenic therapy and irradiation.

as are areas of necrosis. Hyalinized thrombi are occasionally seen, especially in older or treated tumors, together with areas of hyalinized stroma.

The tumor possesses no true capsule. A pseudo-capsule which actually consists of pharyngeal or nasal mucosa, occasionally stretched and atrophic, is noted in non-ulcerated specimens (Fig 4).

Although malignant transformation has been reported by others (Shaheen,²⁶ Jackson,¹⁵ Dabney⁵) the presented evidence is inadequate and unconvincing, in our opinion. No tumor in the present series underwent malignant

transformation, anatomically or clinically, with the exception of a single case in which one of numerous recurrences revealed unusual cellularity and localized areas of malignant transformation, subsequent recurrences, however, during a period of three years were reported as benign and there have never been any clinical manifestations of malignant behavior. This case will be referred to again under prognosis.

SYMPTOMS, MORBID ANATOMY AND CLINICAL COURSE

The first symptom of nasopharyngeal fibroma is probably always *nasal obstruction* which, if only moderate in degree, may for a time pass unnoticed



FIG 4—Surface Appearance of Nasopharyngeal Fibroma. The neoplasm has no true capsule. In this microphotograph intact mucosa may be seen stretched over the tumor, forming a pseudocapsule.

While in a few of our cases the patients at first gave epistaxis as the initial symptom, closer questioning almost always elicited a preceding history of nasal obstruction to which little attention had been paid. In order to produce nasal obstruction, we estimate that a tumor in the nasopharynx must reach the size of about 2.5 cm. in diameter, although in the choana a smaller mass could undoubtedly produce this symptom. At any rate there is probably a silent period of at least several months before a growing nasopharyngeal fibroma becomes large enough to cause some obstruction to breathing.

The second symptom of nasopharyngeal fibroma and the one which most often causes the patient to seek medical advice is *recurrent epistaxis*. Hemor-

rhage probably occurs either as a result of trauma to the tumor, incident to sneezing or to forcibly blowing the nose, or from pressure necrosis of the expanding growth as it meets with the resistance of the confining bony walls. Once initiated, hemorrhages occur at increasingly frequent intervals, especially when their control necessitates tamponage or nasal packing. These manipulations, when repeated, almost always result in sepsis which may extend to the paranasal sinuses, the middle ear, and even the mastoid. With recurrent hemorrhages, the patient becomes anemic and since proper nutrition is interfered with by local manipulations, usually loses considerable weight.



FIG 5—Facial Deformity in Nasopharyngeal Fibroma (a) Marked facial deformity may be produced by a bulky nasopharyngeal fibroma as the mass grows outward compressing the antrum and pushing the soft parts of the cheek ahead of it. Removal of this tumor necessitated resection of the anterior wall of the maxilla and corresponding alveolus after reflecting a cheek flap. (b) Postoperative photograph.

If hemorrhage is not an early or frequent symptom and the nasal obstruction is ignored, the tumor may attain sufficient size to cause "frog face" deformity so often mentioned in the surgical literature of the 19th Century.* Such a degree of facial deformity, consisting of prominence of the cheeks and

* "Frog-face" deformity is a clinical manifestation associated with lesions other than juvenile nasopharyngeal angiofibroma. Benign and malignant neoplasms of the nasal cavity, nasopharynx, and maxilla not infrequently occur in children, such as ossifying fibroma, sarcoma of the soft parts, lymphomatous tumors, and central myxoma. As the growth expands and advances, the floor of the orbit is elevated (unilateral or bilateral), producing "frog-face" deformity.

JUVENILE NASOPHARYNX

nose, obliteration of the naso-labial groove, and prominence of the eyes, was present in about one-quarter of our cases on admission (Fig 5) The character of the deformity results not only from the expansion of a growing bulky tumor but sometimes from the particular direction that a growth has taken from its point of origin

Most of the tumors appear to have origin in the vault of the nasopharynx or at least mainly in the vault and the immediately adjacent lateral or posterior nasopharyngeal walls The base of attachment of the growth is usually rather broad (2-3 cm or more) so that the exact point of origin and extent of attachment is difficult to delineate either by clinical examination or operative exposure

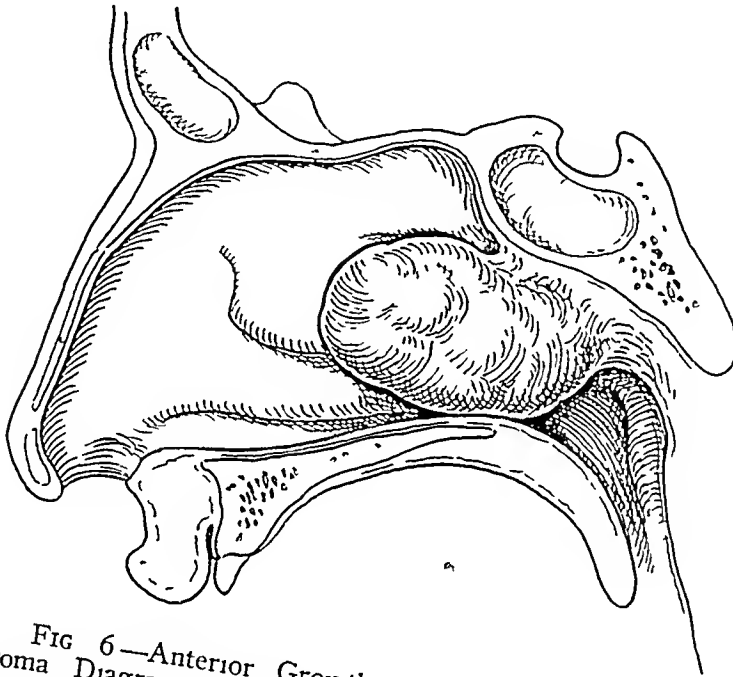


FIG 6—Anterior Growth of Nasopharyngeal Fibroma Diagram of nasopharynx (sagittal view) showing a common location for nasopharyngeal fibroma The tumor arises from one of the walls of the nasopharyngeal cavity or posterior nasal space and grows downward and forward blocking one or both choanae

As the tumor enlarges and expands it may grow forward into the nasal cavity (Fig 6), often presenting at one anterior naris as an edematous partly necrotic mass, in other cases the growth extends backward to protrude below the free edge of the soft palate, some proceed laterally, perforating by pressure necrosis the maxilla to enter the antrum and even appearing in the subcutaneous tissues of the cheek (Fig 7) A large growth occasionally produces pressure on the floor of the orbit and causes elevation of the globe with resultant unilateral exophthalmos In any case, the main mass is always in the nasopharynx

The osseous walls of the nasopharynx are formed by the body of the sphenoid bone, the basilar portion of the occipital bone, the medial pterygoid

plate, and the cervical portion of the vertebral column. The union of these bones, the fascial and tendonous structures which are attached to them, together with variously sized recesses produced by numerous mucosal folds and the cartilages of the eustachian tube (torus tubarius, fossa of Rosenmüller, etc.), contribute to the unusual irregularity of the walls of the nasopharyngeal cavity. This irregularity makes complete surgical removal of a densely adherent broadly attached tumor, like nasopharyngeal fibroma, difficult if not impossible. The peculiarities of the surgical anatomy of nasopharyngeal fibroma will again be referred to in the section on treatment.

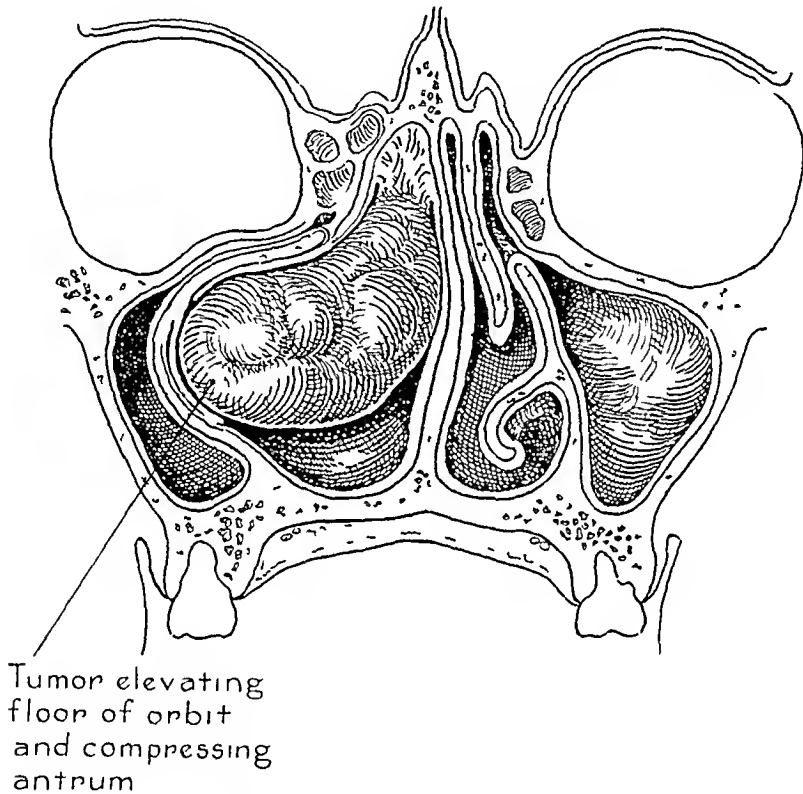


FIG. 7—Lateral Growth of Nasopharyngeal Fibroma. Diagram of nasopharynx (coronal section) showing direction of growth frequently taken by nasopharyngeal fibroma. After plugging the posterior nasal cavity, the tumor compresses the antrum, expands laterally into the maxilla, and may eventually reach the soft tissues of the cheek.

As an expanding tumor closes off the nasopharynx, voice changes may occur (*rhinolalia clausa*) and, also, a loss of sense of smell. In our series, there is no instance of erosion of the base of the skull, although it has been described by Goldsmith¹⁰.

The usual history in patients with juvenile nasopharyngeal fibroma applying to Memorial Hospital followed a rather definite pattern: an acute onset of recurrent epistaxis in boys from 12 to 15 years of age, usually preceded by

progressive nasal obstruction to which little or no attention had been paid. With each incidence of epistaxis, the nose had been packed and the hemorrhage temporarily arrested, only to recur with increasing frequency and severity. In most of the protracted cases there was marked local sepsis and sometimes partial necrosis of the tumor.

In about one-half of the cases in our series, previous operative attempts to remove the tumor had been made, frequently through the mouth and sometimes by splitting the soft palate. Usually two or three and in one case five operative efforts had been made. In almost every instance where surgical removal had been undertaken, the operator admitted that he had abandoned the attempt to completely remove the growth because of ensuing hemorrhage. In about 50 per cent of these failures, the diagnosis of "sarcoma" was made, the case was given up as hopeless, and the patient was referred to Memorial Hospital for palliative roentgen-ray therapy. In some of the cases, prior to referral to us, snare removal of a "nasal polyp" had been tried, or the bleeding point had been cauterized, or, in five cases, tonsillectomy and adenoidectomy had been performed in the belief that the tonsillar hypertrophy was the cause of the symptoms. All of these efforts had been followed by an increase in nasal bleeding.

In advanced and complicated cases such as described above, especially after incomplete surgical removal, there is usually an ill-defined, bulky, infected, partly necrotic, vascular tumor filling the nasopharynx and extending into one or both nasal cavities. The picture is sometimes one of subacute sepsis, pansinusitis, otitis media, mastoiditis, anemia, and malnutrition which, if unrelieved, results fatally despite the fact that the neoplasm is essentially benign and self-limited in growth.

In contrast to the tragic picture of the advanced and neglected cases, many others, properly managed, follow a relatively benign course provided that the symptoms of an expanding growth and hemorrhage can be kept under control. It is probable that some cases of nasopharyngeal fibroma of moderate size occur and regress spontaneously without ever being discovered or producing any marked symptoms. We have under observation at Memorial Hospital a case in which a nasopharyngeal tumor, undoubtedly a nasopharyngeal fibroma, was discovered by us on routine physical examination in a 15-year-old boy. The growth was not large enough to produce nasal obstruction and there had been no epistaxis. No treatment has been given. The tumor has been observed for two and one-half years and has remained about stationary in size. It is probable that such asymptomatic nasopharyngeal fibromas may often occur and regress when sexual maturity is reached.

DIAGNOSIS

The histories of the 29 cases in the present series reveal that the correct diagnosis was seldom made by the physician first consulted. In many instances a clinical diagnosis of malignant tumor was made and without further inves-

tigation radiation therapy was advised, in other cases, after an unsuccessful attempt to remove the growth or the adenoids had been made, resulting in profuse hemorrhage, the patient was referred to us for treatment of "sarcoma." Such defeatist attitudes were the rule if the boy presented appreciable facial deformity or proptosis. Only occasionally, when a biopsy had been performed, had an accurate diagnosis of juvenile nasopharyngeal fibroma been made.

Although the tumor is admittedly rare and on the basis of incidence will not be recognized by the casual examiner, nevertheless the unique anatomic and clinical setting of this neoplasm should plainly suggest the possibility of nasopharyngeal fibroma. The clinical syndrome of rapidly progressive nasal obstruction, recurrent severe nosebleeds in *pubescent and adolescent males*, plus the presence of a discrete, ovoid or club-shaped, smooth, vascular and usually bulky nasopharyngeal mass, which has grown forward to block one or both choanae, justifiably warrants a clinical diagnosis of nasopharyngeal fibroma. It should be emphasized, however, that only by mirror examination of the nasopharynx through the open mouth, occasionally supplemented by direct rhinopharyngoscopic examination through the anterior nares, can the tumor be visualized and its essential character appreciated.

Stereoscopic radiographic examination of the base of the skull, paranasal sinuses, and nasopharynx is not only of value in determining the exact location and extent of the tumor, but is especially important in the differential diagnosis where a bulky growth in the head has brought about considerable deformity of the face or unilateral exophthalmos.

Differential Diagnosis. There are several extra-nasopharyngeal lesions which produce either nasal obstruction, epistaxis, unilateral exophthalmos, deafness, or facial asymmetry, singly or in combinations. Asymptomatic tumor-factions may also be encountered in the nasopharyngeal or posterior nasal cavity which are occasionally mistaken for juvenile nasopharyngeal fibroma.

Choanal polyps can be distinguished from nasopharyngeal fibroma even when they occur in boys. These growths are frequently multiple, bilateral, pedunculated and tend to appear in individuals suffering from an allergy. They rarely exceed 1.5 to 2 cm. in diameter and resemble in every way the common and well-known pale, edematous polyps found in the anterior nasal cavities. Microscopic examination of the tissue conclusively establishes the diagnosis.

Pharyngeal tonsil (adenoids) is a common cause of nasal obstruction and nasal speech in juveniles. Hyperplastic lymphoid or granulation tissue in the nasopharynx may even be responsible for recurrent nosebleeds, although rarely profuse. There should be no difficulty in differentiating this condition from nasopharyngeal fibroma inasmuch as aggregates of lymphadenoid tissue, generally on the posterior nasopharyngeal wall, present a typical appearance consisting of irregular, conglomerate, soft, grayish-red masses which are distributed along the mucosa.

Benign minor salivary gland tumors, carcinoma, and malignant lymphomas, though uncommon in the head and neck of children and adolescents,

occur with much greater frequency in the nasopharynx and posterior nasal cavity than nasopharyngeal fibroma and, although they may produce symptoms similar to those of nasopharyngeal fibroma, in no way resemble it on clinical examination

Chordoma of the upper cervical vertebrae, malignant tumors of the nasal accessory sinuses, and primary osseous neoplasms of the maxilla may produce nasal obstruction, epistaxis, and facial asymmetry, but by careful physical and roentgenographic examination these lesions can be tentatively diagnosed and differentiated from nasopharyngeal fibroma with little difficulty. We have seen chondroma in the posterior nasal cavity, tuberculosis of a retropharyngeal lymph node, and olfactory aesthesioneuroblastoma in the postnasal space, which clinically resembled nasopharyngeal fibroma in every way

Biopsy—An effort should always be made to establish the diagnosis by biopsy. It is prudent to hospitalize the patient for this procedure so that, if necessary, satisfactory anesthesia and facilities for control of profuse hemorrhage and for blood transfusions can be available. Deferment of biopsy is often wise if the patient is either bleeding actively or still recuperating from severe epistaxis or if there is appreciable infection in the nasopharynx, paranasal sinuses, or middle ear

A straight biopsy forceps inserted directly backward through the nasal cavity or a curved forceps inserted through the open mouth may be used to remove a specimen from a nasopharyngeal tumor. The manipulations in either instance should be guided visually by a mirror or digitally by a finger

Although biopsy is highly desirable and usually essential in the diagnosis of neoplasms, it must be conceded that in some cases of nasopharyngeal fibroma, despite the best of intentions, a positive histologic report cannot be obtained. In some cases, a recurrent growth, after several operative attempts, is largely necrotic and the local condition in the nasopharynx is one of advanced sepsis. Repeated biopsies in such instances may show nothing more than necrosis or granulation tissue. If the case is clinically typical in all other respects (age, sex, characteristic sequence of symptoms, anatomic location, gross appearance of the tumor), the diagnosis of nasopharyngeal fibroma may fairly be made even though not confirmed by a positive biopsy

In our clinic where primary histologic confirmation is insisted upon, we nevertheless felt justified in making a diagnosis of nasopharyngeal fibroma in five cases in which a positive microscopic report on the biopsy specimen could not be obtained, despite repeated attempts at biopsy in three of these. The subsequent clinical course of these patients confirmed our initial belief that we were unquestionably dealing with nasopharyngeal fibroma

TREATMENT

A basic consideration in the treatment of nasopharyngeal fibroma is the fact that this tumor is anatomically and clinically benign, that with few exceptions it will begin to regress spontaneously at about the time of sexual maturity, and from then on will cause no further trouble. The real hazards consist

of the complications—hemorrhage, sepsis, facial deformity, and last but not least the effects of injudicious and over-aggressive attempts at complete eradication of the growth by surgery or radiation therapy. Provided that the aforementioned complications can be kept under reasonable control during the period of adolescence by moderate irradiation or limited surgery, and sex hormone therapy, spontaneous regression almost uniformly occurs at the time of sexual maturity.

The types of deforming surgical procedures particularly to be avoided in nasopharyngeal fibroma are approaches through the skin of the middle of the cheek (Langenbeck¹⁶), temporary detachment of bone (Ollier²²) or exposure of the nasopharynx by splitting the soft palate. We shall discuss the more restrained and judicious forms of surgical procedure later in this report.

By over-aggressive and injudicious radiation therapy we mean any dose of interstitial radium (or radon) which is likely to produce radionecrosis in the tumor or adjacent palate, skin of the face or bones of the skull, or the application of roentgen-radiation in such dosages and through ports so located and of such size as to arrest or markedly retard the growth of the maxillae and other facial bones.

Once a diagnosis of nasopharyngeal fibroma is made, a systematic plan of management should be instituted, consisting of a combination of at least two and sometimes more methods of treatment. First, if epistaxis has been marked, both external carotid arteries should be ligated and measures taken to improve the local hygiene, dispensing, if possible, with any nasal packing or tamponage which inevitably incites a vicious cycle of further hemorrhage, repeated tamponage, and sepsis. Next, the administration of androgens adequate to induce the development of secondary sex characteristics without undue emotional imbalance should be instituted. The amounts of testosterone propionate and/or methyl testosterone required probably are very different for each individual and may be a function of his chronologic and "developmental" ages. At the same time radiation therapy (radium or roentgen-ray or both) should be given. Lastly, if the tumor is so large as to produce complete blockage of the nasal cavity with an edematous, partly necrotic mass or with symptoms of pansinusitis, then some form of partial surgical removal should be considered. The rationale and technic of these several therapeutic programs will next be discussed separately and in detail.

Ligation of the External Carotid Arteries—This is one of the most direct and useful procedures in controlling arterial hemorrhages from any portion of the mouth, middle or upper pharynx, and nasal cavities. It is an entirely safe and harmless procedure to ligate permanently both external carotid arteries at one operation. Ligation of these blood vessels will not always completely control hemorrhage from the nasal cavities and nasopharynx, but it will markedly reduce it.

While a portion of the arterial supply of the nasal cavities is derived from the internal carotid artery by way of the ophthalmic artery and its anterior and posterior ethmoidal branches, this source can hardly cause any major difficulty

A much more troublesome source of hemorrhage from the nasopharynx and nasal cavities is venous—from the pterygoid plexus which communicates not only with the anterior facial vein but also with the veins of the cranial cavity by way of the superior ophthalmic vein. In any case, as compared with arterial hemorrhage, venous bleeding tends to be less profuse and the relatively low venous pressure may more easily be controlled by temporary light tamponage.

Sex Hormone Therapy—This form of therapy can be started immediately in all cases without interfering with any other treatment measure. A clinical evaluation of the status of sexual development should be made by frequent examinations to determine any change possibly brought about by androgenic therapy. The state of the ossification centers, the level of urinary excretion of 17-ketosteroids, careful evaluation of secondary sex characteristics and emotional changes should be made at frequent intervals.

We had hoped at first to be able to control nasopharyngeal fibroma by endocrine therapy alone. This has not proved possible in the few instances in which its limited use has been employed. We have noted in these instances a definite and gradual elimination of the hemorrhagic tendency of the tumors associated with an acceleration of sexual maturation. In particular this association was observed in the case of an 18-year-old male who was treated for several months with limited benefit by radiation therapy. The intramuscular administration of 25 mg of testosterone propionate four times each week effected a marked change of his secondary sex characteristics and a rapid disappearance of the tumor in the space of one month.

Roentgen-ray Therapy—Practically all hemangiomatous lesions are at least moderately radiosensitive. Fibrous tissue and fibromas in general are not radiosensitive. In our opinion radiation therapy is useful in nasopharyngeal fibroma mainly as a measure to reduce the angiomatous component of the tumor, thereby assisting in the control of the hemorrhage and to some extent in the arrest of its growth. We think it doubtful that radiation therapy in justifiable dosage can have much direct effect on the fibromatous elements of this neoplasm.

Radiation therapy is immediately indicated in bleeding nasopharyngeal fibroma but is of less value as initial treatment in bulky (6–8 cm) edematous tumors in which the clinical picture is mainly one of facial deformity and nasal obstruction from an expanding tumor. Roentgen-ray therapy can be instituted promptly, preferably through the open mouth and hard palate in posteriorly placed growths. Additional roentgen therapy may also be given externally through the maxillae, but here some thought should be given to the possibility of permanent damage to the development of the facial bones. We have never been able to determine exactly what dose of roentgen therapy can be given safely over the germinal centers of growing bones. In general, we suggest in nasopharyngeal fibroma not more than 1000–1500 r in divided doses through circular portals 5 cm in diameter over each maxilla (200–250 K V, 50 cm TSD, 1–1½ mm copper filtration). Even this dose may result in some

flattening of the cheeks as the boy reaches full stature. The dose through the hard palate may be greater (2000–2500 r) with less danger of late deformity, employing peroral circular or oval portals 3–4 cm in diameter. By cross-firing the tumor through these three portals, a significant roentgen-ray dose can be delivered into the tumor site.

Radium Therapy—If the growth is bulky (5 cm or more in diameter), no significant radiation dose which may be considered safe can be distributed throughout the mass by interstitial radium or radon. If the tumor is extremely vascular, the insertion of a trocar for implantation of seeds or the introduction of a radium needle is attended by profuse hemorrhage, necessitating immediate and firm tamponage. Under such conditions, the procedure appears to cause as much harm as good even though the radiating sources remain in place.

Radium therapy in the form of gold radon implants is one of the most useful methods for control of nasopharyngeal fibroma provided the tumor is less than 5 cm in diameter and the dosage is fractionated and combined with other forms of treatment such as supplemental roentgen-radiation to the cheeks and palate and hormone therapy. Seeds in doses of 5–6 mcs (unit strength 1–1.5 mcs) can be inserted either through the nasal cavity and/or the soft palate with the aid of the exploring finger passed behind the soft palate into the nasopharynx. The dose may be repeated once or twice at intervals of about a month. Delevan⁶ and Figg⁹ have recommended that the main reliance be placed on this method of treatment. Radon seeds are also useful for the treatment of residual tumor or re-growth after surgical removal of large neoplasms which were too bulky for control by radiation therapy in the beginning.

Surgical Excision—It is not possible to obtain even a moderately wide surgical exposure of the nasopharynx except by operative procedures which are not only immediately hazardous but also permanently deforming and disabling. Whether the surgical approach is made through the maxilla anteriorly, the alveolar process, or the palate, the permissible size of the opening through the bone is limited to 3–4 cm, and the destination of the approach, that is the cavity of the nasopharynx, is at a depth of 9–10 cm from the surface. Deliberate and continued surgical dissection at such a depth in a highly vascular zone and through such a narrow aperture is simply not possible. For these technical reasons, and the almost inevitable postoperative recurrence, surgical removal of nasopharyngeal fibroma, except when absolutely necessary, has never been regarded enthusiastically by experienced observers. Nevertheless, in the larger tumors with marked facial deformity and progressive destruction of the maxilla or other adjacent bony structures by pressure necrosis, the bulk of the tumor should be removed or at least reduced by some expedient other than radiation therapy. To this end several methods have been employed by others, such as avulsion by wire snare through the nasal cavity or mouth, destruction of the tumor *in situ* by endothermy, and by the direct trans-maxillary surgical approach.

We have used several methods for the surgical removal of these and other varieties of tumors in the naso-pharynx, the selection depending mainly on the position and surgical anatomy of the growth. In some cases where the nasopharyngeal fibroma was not too large, we have employed the wire snare or simple avulsion by digital manipulations through the anterior nares and mouth. Such simple maneuvers have at least the advantage of being non-deforming. In others, we have approached the nasal cavity and nasopharynx through an incision in the upper gingivobuccal gutter (Rouge), but have found that unless a considerable portion of the nasal bones and nasal septum are rongeué away this approach has little advantage over simple dilation of the anterior nares. In some cases where the tumor extended directly forward through the antrum and anterior wall of the maxilla, we have developed and reflected a cheek flap (Weber-Ferguson incision), exposing the tumor directly from the front. One of the most useful, least deforming, and least disabling approaches to the nasal cavity and nasopharynx is through the alveolar process anteriorly, just to one or the other side of the midline. If teeth are present, about 4 or 5 are extracted, and the entire thickness of the alveolus removed exposing both the antrum and nasal cavity on that side. The party wall between the nasal cavity and the antrum is then rongeué away and a fairly wide exposure of the nasopharynx obtained with adequate accessibility to the ethmoid and sphenoid sinuses. The latter operation is followed by surprisingly little disability. The opening in the alveolus shrinks down to about 2 cm in diameter and a dentist can provide a prosthesis which completely covers the defect, inconveniencing the patient no more than would an ordinary full upper dental plate.

After the anterior aspect of the tumor has been exposed by an adequate trans-maxillary approach, the growth must be further mobilized from its attachment at the base. If it were possible to dissect the mass from the underlying bone, periosteum, or fascia, it would then be feasible to enucleate the tumor in its entirety. Due to the irregular bony walls of the nasopharyngeal cavity, however, in addition to the generally broad dense attachment of nasopharyngeal fibroma, complete surgical removal of the neoplasm cannot be effected, unless it is limited to the basilar portion of the occipital bone where the surface is smooth. Residual tumor, therefore, will almost always be left behind, despite the good intentions of the surgeon. In many cases appreciable recurrences, frequently ulcerated and infected, will appear and have to be treated with interstitial radiation.

The indication for any given method of surgical removal must be decided by the clinical setting in each case. The selection of the proper time for operation may also be important. In general, we suggest deferment of any surgery in cases without marked deformity, hemorrhage, or sepsis. Such cases should be continued indefinitely under sex hormone and radiation therapy. Where hemorrhage is a serious complication or where surgical removal of the tumor is contemplated, a bilateral ligation of the external carotid arteries should first be made, hormones given, and radiation therapy instituted. By these less

aggressive measures, the hemorrhages may be arrested and the tumor reduced in size or at least brought under control. In any case, these preliminary precautions will markedly reduce the amount of bleeding at operation, if this finally becomes necessary.

TABLE I—*Juvenile Nasopharyngeal Fibroma*
Tabulation of Methods of Treatment and Their Complications

Method of Treatment	Number of Cases	Case Number	Complications
A X radiation	9	4 8** 9** 11 12 13** 15** 19** *20**	Dryness of nasopharynx Atrophy of maxillae None Dryness of nasopharynx None None Otitis media, coarse features Otitis media Died of rheumatic fever
B Interstitial radiation	5	3 5 *7 21 29**	Necrosis of palate Dryness of nasopharynx Pansinusitis None None
C Interstitial and X radiation	2	2 6	Dryness of nasopharynx Dryness of nasopharynx
D Surgical excision	4	*22 *24 *25** *26	None None None None
E Surgical excision combined with X radiation	1	*27	None
F Surgical excision combined with interstitial radiation	2	1 *28	Died of brain abscess None
G Surgical excision combined with interstitial and X radiation	4	*10 *16** *17 *18**	Died of brain abscess Necrosis of hard palate Otitis media None
H Hormones only	1	14	None
I No treatment observation only	1	23	None

* Ligation of external carotid arteries

** Received hormone therapy

METHODS OF TREATMENT SUMMARIZED AND COMPARED

Once the diagnosis of juvenile nasopharyngeal fibroma has been established, a therapeutic program should be adopted, subject to change as required by ensuing clinical developments. As already mentioned, there is no one type of treatment which is a panacea for any given case and in practically all instances a combination of methods must be employed. Obviously, aside from

periodic examination, an active therapeutic regimen is not indicated for the occasional case where the tumor is discovered during routine physical examination with no symptoms referable to it. In the absence of nasal obstruction, nose-bleeds, impairment of hearing, infection of the paranasal sinuses or middle ear, facial deformity, exophthalmos, headache or any discomfort about the head, or evidence of progressive enlargement or significantly increased vascularity of the neoplasm, a policy of watchful waiting is justified. This policy was followed in the case of one of our patients, age 15 on admission, and during a two-year period of observation the growth has remained stationary and asymptomatic.

Endocrine therapy was the only form of treatment which was prescribed in one case. In ten others it was combined with some form of radiation therapy, surgery, or both. With the combination of methods, sex hormone therapy was either utilized alone as the initial treatment and, following its failure to control the growth satisfactorily, radiation therapy was instituted, or both forms of treatment were begun simultaneously. While no definite regression of the tumor was noted in any case in which the patient received only male sex hormone, it was our clinical impression that hemorrhages usually diminished in frequency and severity following the use of hormones. The basis for this observation may be due to the considerations included under etiology.

In our series, some form of radiation therapy, either alone or combined with one or more surgical procedures, was resorted to in 23 cases (Table I). In nine of these, roentgen therapy was the only form of radiation employed and in this group late complications (dryness of nasopharynx, atrophy of maxillae, coarsening of features), attributable to the high dosages used to control the tumor, were frequent, indicating that no one method of treatment can be depended on without courting the hazards of over-aggressiveness. Because of its possible effect on the growth centers of the facial bones, roentgenradiation should preferably be reserved for patients 18 years of age or older.

Interstitial radiation therapy was employed alone in five cases and was followed by serious complications in three instances. In one, necrosis of the hard palate resulted, due to an unnecessarily large dose of gold seeds (total of 34 mcs inserted at three sittings over a period of two years). In two, even more unfortunate developments followed massive doses of interstitial radiation (total dose of 32 mc in one, 20 mc in another after administration of 3000 r of 200 K V therapy through a single 6 cm cheek portal). Both patients developed extensive osteonecrosis extending into the sphenoid bone and finally succumbed to brain abscess. At that time, about 20 years ago, we believed it essential to eradicate the growth completely in order to cure the patient and were not cognizant of the fact that simple control of tumor activity until sexual maturity had been attained was all that was necessary.

From an analysis of our data, it is noteworthy that as a rule smaller doses of interstitial and roentgenradiation will effectively control symptoms if the patient is receiving continued and adequate endocrine therapy, that bulky

tumors producing facial deformity or exophthalmos are followed by no complications when treated by primary surgical excision (four cases), and that residual tumors can be readily controlled with small doses of gold seeds inserted at frequent intervals

During the period of radiation therapy, suppuration in the nasal accessory sinuses or middle ear occasionally supervenes and rarely mastoiditis may occur. Such sepsis, together with the untoward systemic effect of radiation therapy in general, makes hospitalization for the treatment of many of these patients mandatory. In this way local hygienic care, adequate nutritional therapy, blood transfusions, and chemotherapy are made available.

PROGNOSIS

As has been previously stated, if complications of hemorrhage, sepsis (pansinusitis, otitis media, etc.), and facial deformity by an expanding tumor can be prevented or even markedly reduced, little or no harm can come to the patient with nasopharyngeal fibroma and the growth will regress spontaneously in practically all instances. From a study of our cases it is plain that many of the most serious complications are brought on primarily by aggressive and ill-conceived therapeutic measures, such as poorly planned attempts at surgical removal without preliminary arterial ligation and inadequate exposure of the nasopharynx and secondarily by unduly vigorous endeavors to control further growth by radiation therapy. In such cases the patients would have been much better off without any treatment whatever.

Juvenile nasopharyngeal fibroma is not essentially a malignant tumor. It does not invade adjacent tissues and its destructive capacities are entirely due to pressure atrophy of contiguous structures by the enlarging mass. So far as we know, there is no well authenticated instance of malignant transformation of this tumor. In one case of the present series, the patient developed numerous recurrences, one of which showed on microscopic examination unusual cellularity and localized areas of malignant transformation. Seven subsequent recurrences were examined histologically, however, and none of these revealed any unusual changes. During the three years that have elapsed since the suspected malignant recurrence was noted, the tumor has not shown any evidence clinically of malignant propensities. Although Shaheen²⁶ stated that some of his cases underwent "carcinomatous and sarcomatous" changes, as mentioned earlier in this discussion, his series was not critically selected and in our opinion his conclusions are therefore unacceptable. We suspect that Shaheen's cases of "malignant transformation" were actually malignant nasopharyngeal cancers and not nasopharyngeal fibromas in the beginning. Two isolated case reports of malignant nasopharyngeal fibroma appeared in the literature in 1904 and 1912^{14, 5} but here again the presented evidence is entirely unconvincing. Some of these errors undoubtedly arose from a mistaken morphologic interpretation of a highly vascular and highly cellular tumor as "angiosarcoma." Although the tumor in Wirth's patient²⁸ in the beginning simulated nasopharyngeal angiofibroma in some respects the predominant

picture was that of chondrosarcoma, and it metastasized as such, since this case is complex and at complete variance with the accepted criteria necessary for a diagnosis of juvenile nasopharyngeal angiofibroma, it would hardly be reasonable to classify it as such

In brief, the prognosis in a case of juvenile nasopharyngeal fibroma properly managed is excellent so far as the question of life is concerned. The greatest hazard both as regards life and permanent disability lies in injudicious treatment either by radiation therapy or surgery. As we have pointed out, the growth is practically incurable from the standpoint of its complete eradication and prevention of recurrences before sexual maturity is attained. After sexual maturity has been reached, however, the growth will disappear spontaneously in most instances.

END-RESULTS

Practically all patients with nasopharyngeal fibroma should recover and become symptom free when sexual maturity is reached. In our series there were two deaths due to brain abscess, resulting from over-dosage with interstitial radiation. A third patient succumbed to acute rheumatic fever just after the onset of treatment for nasopharyngeal fibroma.

SUMMARY

The thesis has been advanced that juvenile nasopharyngeal fibroma occurs only in pubescent males. For other reasons, namely its spontaneous or readily induced regression with the appearance of full sexual development, a sex-endocrine relationship for this tumor probably exists. Although its histogenesis has not been definitely established, a vascular origin is proposed in this report. This proposal is based on specific involutional changes which can be induced with male sex hormone therapy and irradiation. The induction of vascular changes by hormone administration has considerable experimental support.

Even though nasopharyngeal fibroma is essentially benign, it frequently produces serious and disabling symptoms because of its progressive growth and tendency to profuse hemorrhage. The indications, methods, and hazards of both radiation and surgical treatment in combating these symptoms are discussed. The trend on the Head and Neck Service at Memorial Hospital has been to employ one or more of these methods of treatment in an effort to control the growth since, in most cases, spontaneous regression can be expected after sexual maturity. Aggressive measures either by irradiation or surgery will never completely and permanently eradicate the neoplasm and will involve considerable risk of ultimate disability or even death.

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a surgical procedure dealing with the diseased disc has been devised, using the transperitoneal approach with ox bone implantation. The objective, anatomic and physiologic principles, operative treatment, and follow-up statistics are presented.

The object of this procedure is

- 1 To completely remove the entire diseased disc with the cartilaginous end plates of the adjacent vertebrae

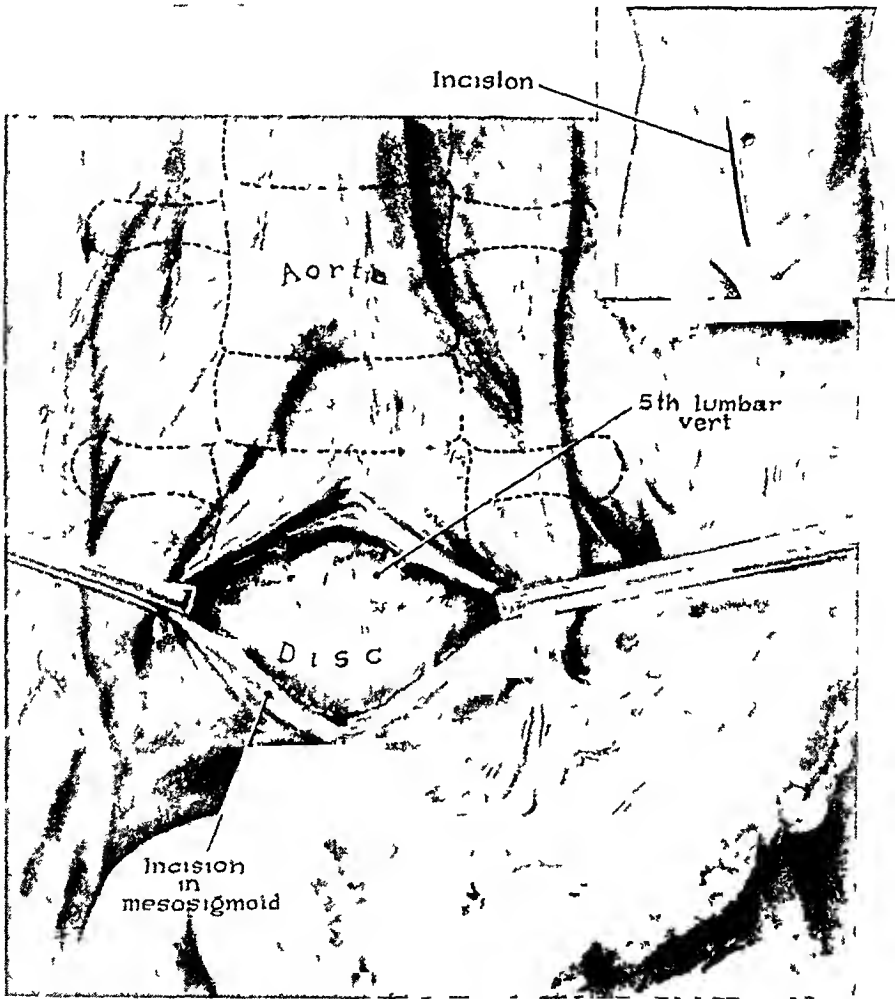


FIG 1—Demonstrates abdominal incision. Important pelvic structures, and location of 5th lumbar disc.

- 2 To wedge the disc space open with an ox bone implantation in order to maintain normal space between the vertebrae until firm bony fusion is obtained.

There are several undesirable features in the posterior approach by partial laminectomy, which have contributed in some degree to the large number of unsatisfactory results. The usual approach by hemilaminectomy fre-

INTERVERTEBRAL DISC

quently gives an inadequate exposure, so that only a small area of the disc space is visualized on the posterolateral side on which the laminectomy is performed. If the herniation of the diseased disc is in the intervertebral canal more anteriorly, it may not be visualized. In exposing the disc, retraction of the nerve roots may result in permanent damage or irritation to these structures. Hemorrhage from the anterior longitudinal veins often prevents

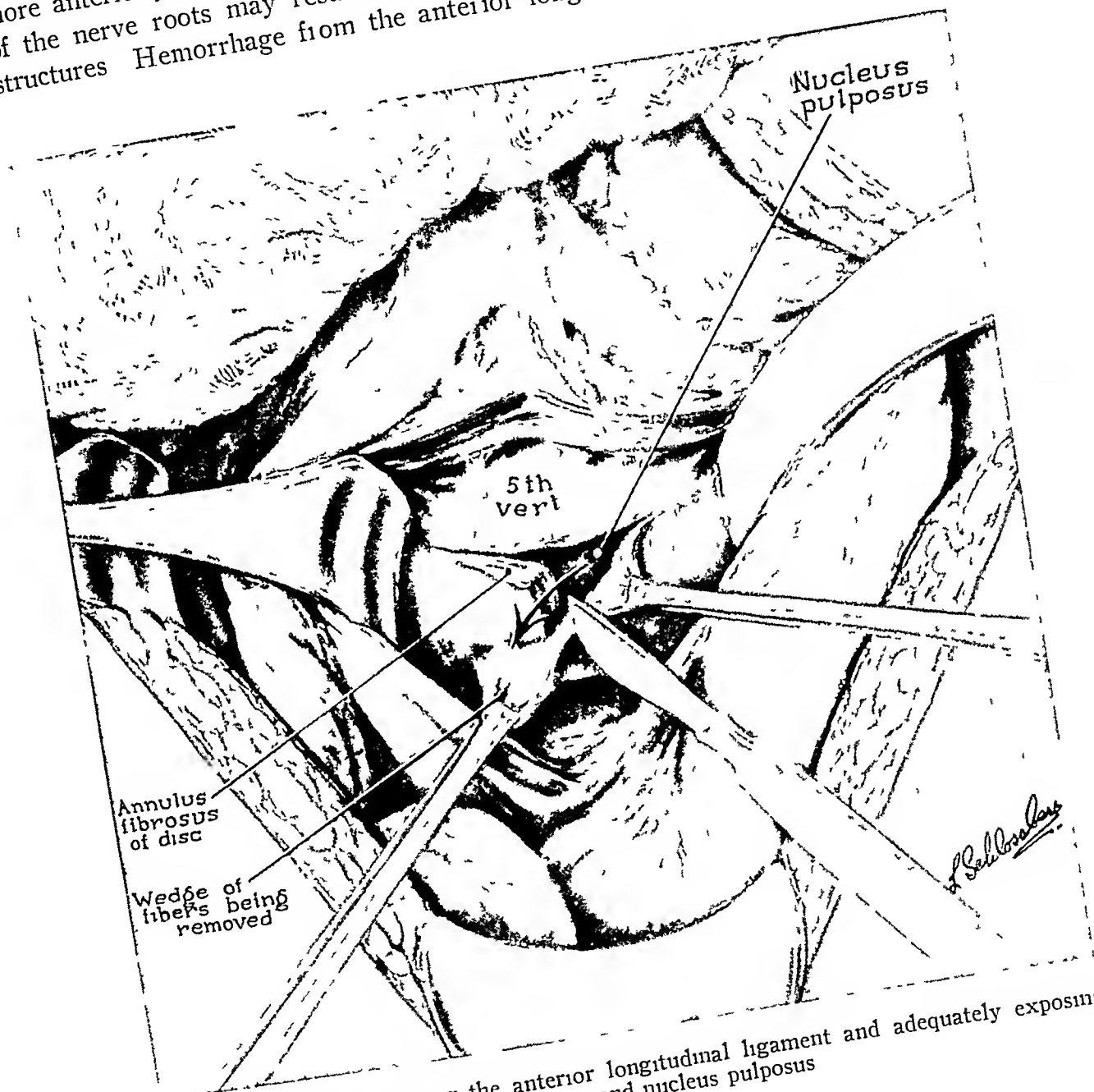


FIG 2—Method of opening the anterior longitudinal ligament and adequately exposing the disc space and nucleus pulposus

adequate vision in demonstrating the lesion and has been found to be a factor in causing postoperative sequelae by hematoma formation followed by fibrosis and nerve root irritation with dural adhesions. Only a small portion of the disc and cartilaginous end plates can be removed by the posterior approach. Since the annulus fibrosus has been damaged, more trauma to the disc can

produce a further herniation of the remaining nuclear material, with a subsequent return of symptoms. Due to removal of the nuclear material, there is a tendency, first, toward subsequent narrowing of the disc space with resulting imbalance of weight bearing between the vertebral bodies and the corresponding facets and, second, joint instability. We have not obtained the desirable features of bone graft fusion and normal disc space by the posterior approach.

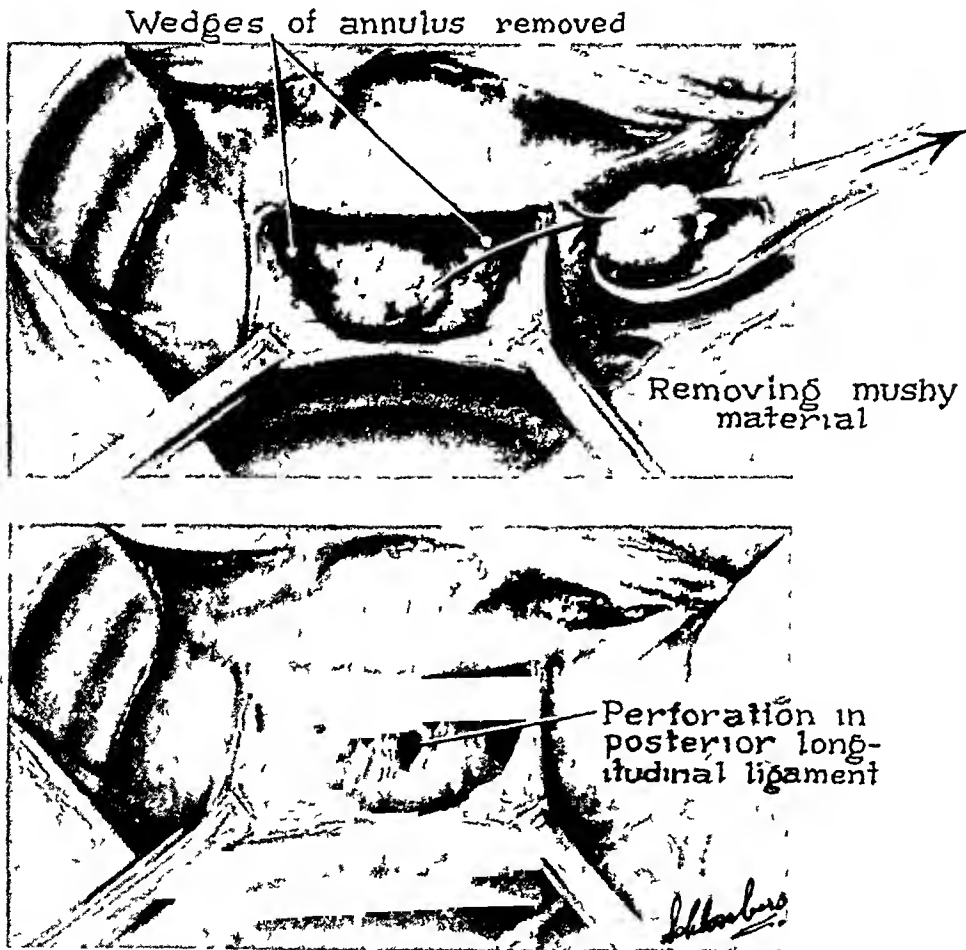


FIG 3—(A) Removal of all material within the disc cavity
(B) Shows exposure of posterior longitudinal ligament with defect after complete removal of disc contents

In removing diseased discs, by the anterior transperitoneal route, the following results, which we believe beneficial, have been obtained (1) Good exposure to the entire disc space and cartilaginous end plates (2) The 3rd, 4th and 5th discs can be examined and treated through the same abdominal incision (3) Removal of the entire disc and all cartilaginous end plates, suffi-

cient to obtain good bony union, can be accomplished (4) Hemorrhage is easily controlled and does not occur into the spinal canal, and no trauma or retraction of the cord or nerve roots are necessary. (5) A large bone implantation can be wedged into the disc space to prevent narrowing until solid bony fusion between the adjacent vertebral bodies has taken place. These are major factors in determining a recovery from symptoms of degenerated disc.

Some knowledge of anatomy of the abdominal cavity is necessary in carrying out the technic of the transperitoneal approach. The blood supply and mesenteric attachments of the lower ileum and colon, the relationship of the pelvic portions of the lower ureter to the spine and great vessels, and the relationship of the lower vena cava and common iliac vessels to the vertebral bodies should be thoroughly understood (Fig 1)

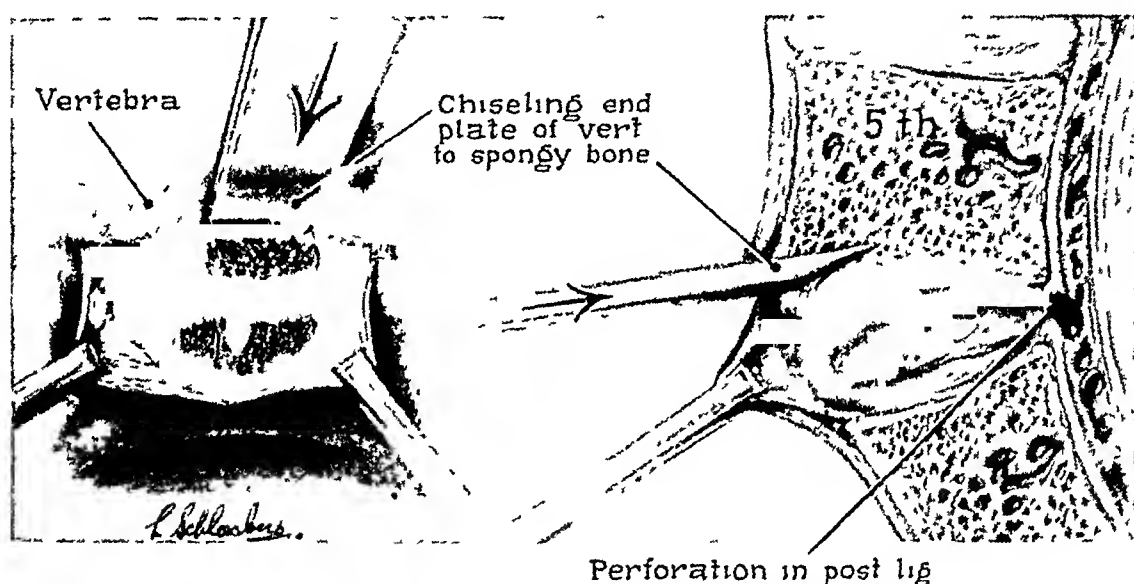


FIG 4—(A) Anterior view demonstrating removal of cartilaginous end plates exposing cancellous bone to promote fusion

(B) Same procedure in cross section

SURGICAL PROCEDURE

In carrying out this procedure, the incision is paramedian from the symphysis to 3 inches above the umbilicus (Fig 1). The rectus sheath is incised 1 inch lateral to the midline, rectus muscle retracted laterally, peritoneum incised, and the abdomen explored for any pathologic condition. Slight Trendelenburg position is obtained to keep the intestines in the upper abdomen. The redundant part of the sigmoid, cecum, and small gut is then displaced in the upper portion of the abdomen and maintained with moist laparotomy sponges to give good exposure to the lower lumbar and pelvic portion of the posterior peritoneum. The pelvic portion of the colon is then retracted to the left, after identifying the ureters. An incision is made in the posterior pelvic peritoneum in the midline, beginning over the sacrum and

extending to the bifurcation of the aorta (Fig 1) The kidney bar on the operating table, previously placed beneath the 4th lumbar vertebra is now elevated sufficiently to push the lumbar spine into hyperextension and forward into the abdominal cavity This gives better exposure and makes as wide as possible the intervertebral disc space in the lower lumbar spine, considerably increasing the access to the space to be opened From 1-2 inches below the

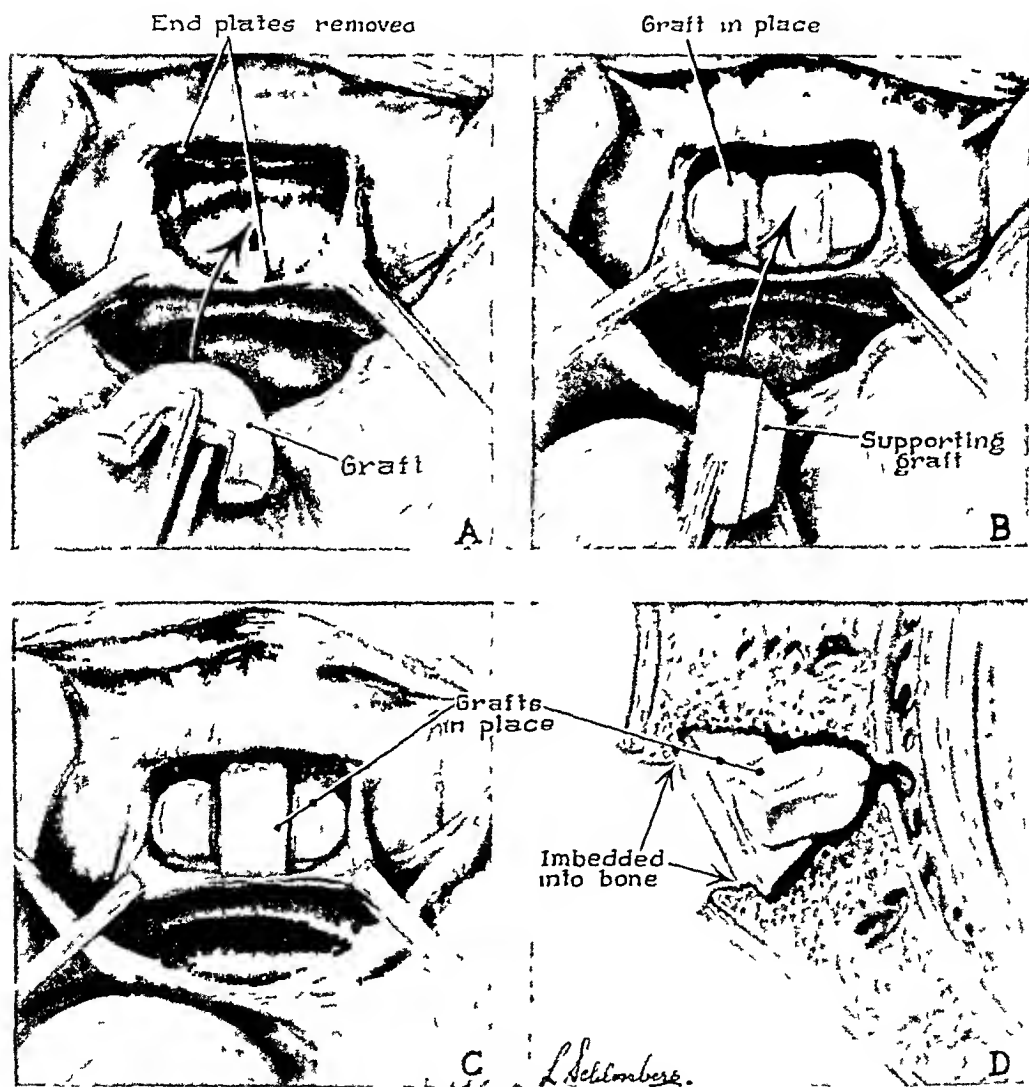


FIG 5—Method of inserting ox bone crescent and peg in disc space

bifurcation of the aorta, the 5th disc is located by palpation between the common iliac vessels and is distinguished by the palpating finger by a distinct elevation with a rubbery consistency as contrasted to the hard vertebral bodies The presacral sympathetic nerve plexus and veins are freed by blunt dissection and retracted to one side, thus completely visualizing the anterior longitudinal ligament over the prominence of the 5th lumbar disc The disc can then be

examined for consistency. By lowering the kidney bar to reduce the lordosis, an estimate of disc narrowing is obtained.

To enter the disc space the kidney bar is re-elevated and a transverse incision made across the anterior longitudinal ligament at the lower margin of the 5th vertebra sufficient to give access to the entire anterior disc space. A vertical incision is made from the mid portion of the transverse incision to the upper margin of the sacrum. This allows for the turning back of a flap of the anterior ligament to give access to the entire nuclear material (Fig. 2). The state of the nuclear material can then be easily ascertained. The contents of the disc space are easily removed by a curette, with a deep cup, and a sharp cutting edge, which facilitates the cutting away of the cartilaginous end



FIG 6—Closure of disc space by suture of anterior longitudinal ligament

plates, as well as the nuclear material. It is necessary for the handles of the curette to be about 8 inches in length, with a cross bar at the proximal end to get sufficient leverage and motion to cut away the bands of the annulus fibrosus and cartilage. The disc contents are removed until the ligaments retaining the disc are visible around the entire disc space (Fig. 3, A & B). Often there is relaxation and bulging of the ligament outward, due to previous degeneration of the disc material, allowing the disc space to narrow and bulge. This outward bulging may be most prominent on either side or posteriorly, and it is always more prominent in these locations than anteriorly since the annuli fibrosi are stronger and several times thicker anteriorly than on the sides or posteriorly. The ligaments at the posterior and lateral sides are then

thoroughly explored with a small blunt instrument to indicate any weakness or defective space at the site where preoperative clinical findings have suggested nerve root pressure. If defects or openings are found, they are further spread open to ascertain if a portion of the nuclear material has been extruded through the defect (Fig 3B). Such material, if found, is removed. After sufficient search has been made to determine that all nuclear material has been excised, the cartilaginous end plates are completely removed from the surface of the vertebrae by a sharp curette or chisel (Fig 4, A & B). This procedure is done last, as it may cause considerable oozing of blood. If done before a thorough search of the disc has been made, it may obscure a defect in the ligament or a portion of nuclear material in the lateral gutter. If bleeding is too free following removal of the end plates, a tight packing with a gauze sponge for several minutes will usually suffice to control it.

To maintain the disc space in its normal width while fusion is progressing, a specially prepared ox bone wedge is used. This was selected on the basis of surgical work previously reported by Orell⁵ working on fractures, in which he demonstrated that ox bone heterogeneous implantations made an excellent bridge and were slowly absorbed over a period of from 12–20 months, gradually becoming a spongy mass through which new capillaries and osteoblasts could permeate and form new bone. This course of events permits gradual replacement of the ox bone wedge by homologous bone from the adjacent vertebral bodies and leaves less chance for narrowing during the fusion process. The ox bone wedge now used consists of a crescent shaped piece with beveled edges, which is driven into the posterior portion of the disc space with the spine hyperextended (Fig 5B). Between the wings of the crescent wedge, a large square bone peg of the same material is driven, being previously measured to fit just inside the wings of the crescent (Fig 5C). This almost completely fills the disc space. Following wedging of the disc space, the flaps of the anterior ligament are closed and sutured over the disc space in their normal position, thus completely encasing the ox bone within the disc space (Fig 6). The kidney rest is lowered, reducing the hyperextension of the spine and spreading the disc space open wider by impinging on the ox bone wedge.

Exposure of the 3rd and 4th disc spaces is slightly more technical than that of the 5th. However, complete visualization can be accomplished. This is due to the fact that the 5th disc lies below the bifurcation of the great vessels, whereas, the 3rd and 4th are beneath the aorta and vena cava. Exposure of the 3rd and 4th is readily achieved for examination, and it is always done if there is any clinical evidence of nerve root irritation or joint instability on examination previous to surgery. This is done by extension upward on the posterior peritoneal incision over the iliac vessels either to the right or left of the midline and along the lateral border of the spine, sufficiently to expose the 3rd and 4th discs. If the incision is on the right side, the ureter is retracted outward and the loose areolar tissue gently dissected through until the lateral border of the vena cava is visualized. A short bladed right

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angle blunt retractor is placed beneath the lateral border of the vena cava, and with gentle retraction it is displaced to the left along with the aorta, until the disc space is adequately exposed. If exposure is done from a left sided approach instead of the right, the incision is the same as that of the right, except that the lateral border of the aorta is encountered first instead of the vena cava. In a like manner the aorta is freed at its lateral border and is retracted toward the right side, with the vena cava, until adequate exposure

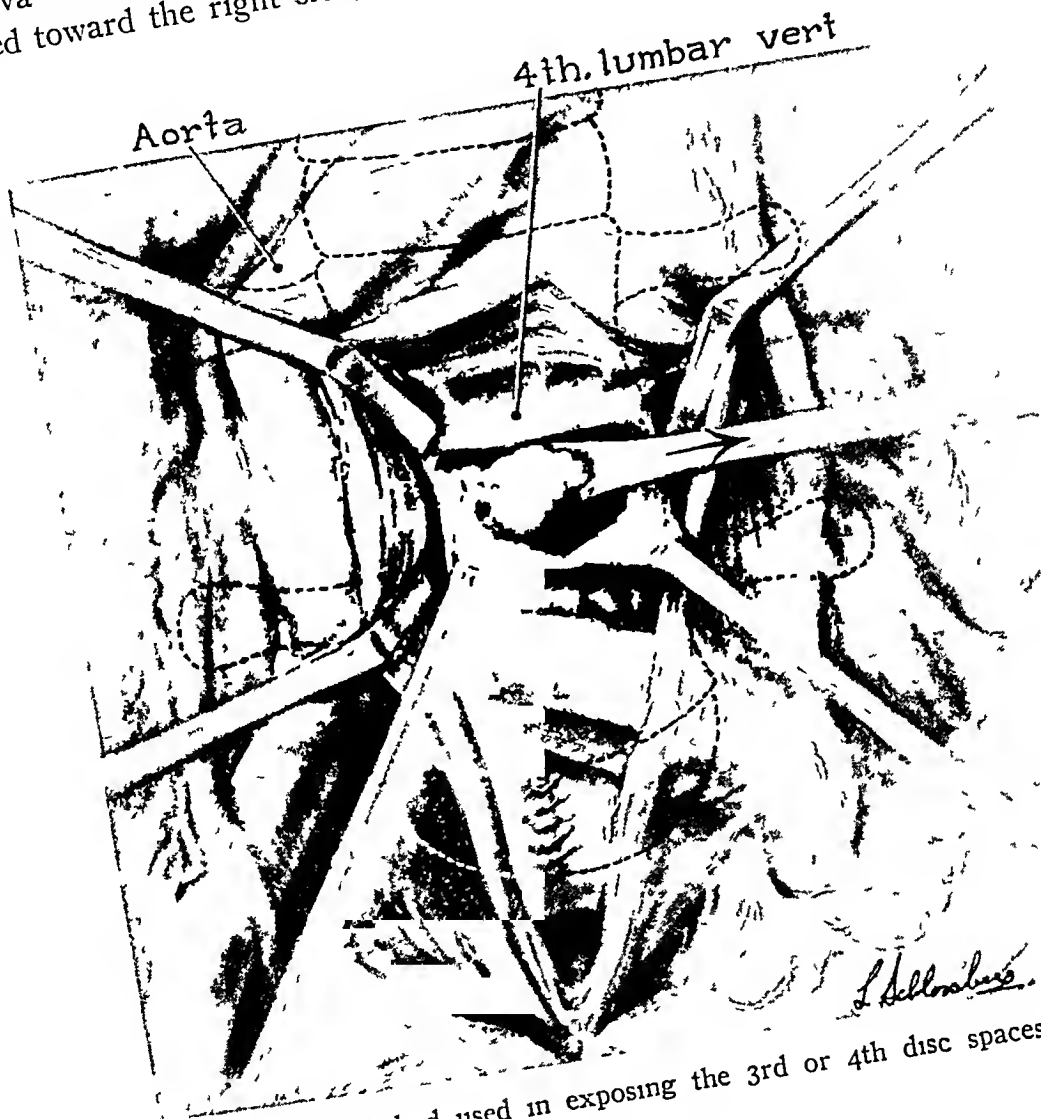


FIG 7—Method used in exposing the 3rd or 4th disc spaces

of the disc space is obtained from this side (Fig 7). If deemed necessary, this disc space may be treated in a similar manner as already described for the 5th. Closure, following the completion of this procedure, consists of suture of the anterior longitudinal ligament to its adjacent vertebra, completely closing the intervertebral space. This is accomplished with sutures of cotton No 30. Closure of the posterior and anterior peritoneal opening is obtained with sutures of interrupted cotton No 70. Fascial layers of the anterior and posterior rectus sheaths are approximated with interrupted sutures of cotton No 30.

POSTOPERATIVE CARE

Postoperative care has been most conservative, in order to arrive at a definite conclusion as to the ideal convalescence which will not interfere with fusion. Measures to combat gaseous distention and phlebitis are followed. The patients are placed in bed with firm rigid support beneath the mattress. No braces or casts are applied at this time. The patients are kept in a supine position on a hard surface for 30 days. X-rays of the lumbar spine are then taken and a body cast is applied to cover the entire lumbar spine and sacrum.

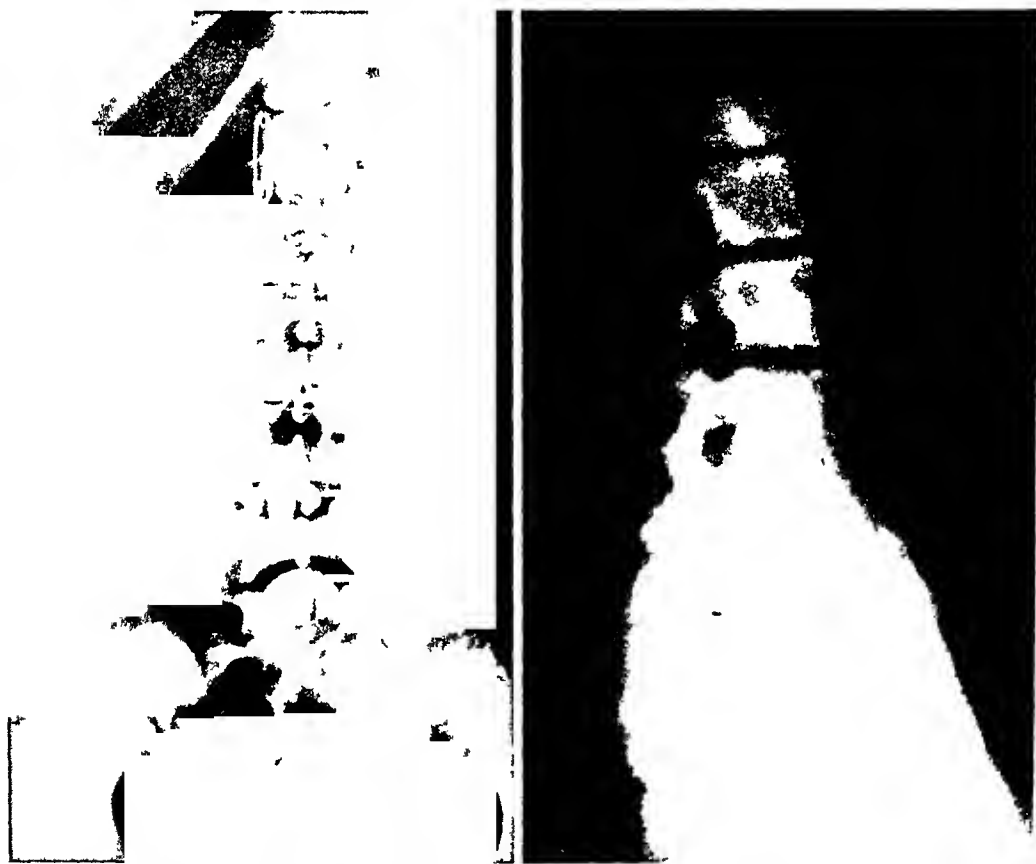


FIG 8—(a) (Left) AP X-ray for position of bone implantations 30 days postoperative
(a) (Right) Lat X-ray for position of bone implantation 30 days postoperative

The lumbar spine is held in slight hyperextension. Some patients have insisted on being out of bed on the 15th postoperative day because they have felt normal. Against our advice, this was done by three patients without support, and they developed no back complaints. The patients are allowed to be ambulant and to return to their homes after the application of the cast and examination, including roentgenograms, for evaluation of progress. If convalescence is satisfactory, they are then supplied with a lumbosacral belt and instructed to refrain from strenuous use of the back; they return at monthly intervals for further check-up examination, including physical examination, check on symptoms, and roentgenograms, to determine the progress of fusion.

This procedure was first started at the Marine Hospital on February 27, 1946, and to the present date all discs requiring surgery have been treated in this manner

CLINICAL MATERIAL

A diagnosis of herniated nucleus pulposus was made in 97 cases admitted to this hospital between February 1, 1946, and February 1, 1947. All patients were treated conservatively by peridural block, traction, or plaster body cast, or a combination of these until such treatment was found ineffectual in the individual case. Thirty-six cases either failed to respond to such treatment or their improvement was insufficient to allow return to a gainful occupation. These 36 cases were subjected to surgery and form the basis of this report.

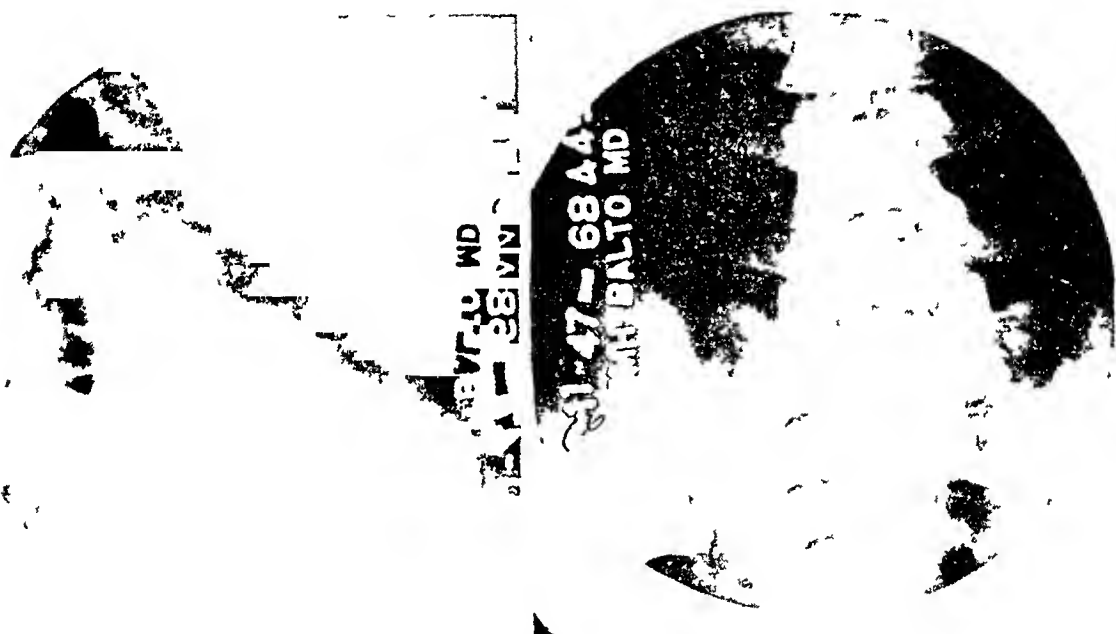


Fig 8—(b) (Left) AP X-ray for progress 5 mos postoperative Fusion present
(b) (Right) Lat X-ray for progress 5 mos postoperative Fusion present

Of the patients undergoing surgery, 29 were males and 7 females. The average age was 31.9 years—the youngest 18 years and the oldest 52. Twenty-nine of the patients followed manual occupations, 7 held sedentary positions.

The average duration of symptoms at the time of surgery was 19.7 months. Of the 36 cases undergoing surgery, 1 case had sciatic neuritis alone, 3 cases had back complaints and findings without neurological changes in the lower extremities, and the remaining 32 cases had back and lower extremity symptoms and neurological findings.

Roentgen examination of the lumbar spine (A-P and lateral) revealed narrowing of the suspected space in 8 cases, evidence of previous partial hemilaminectomy in 4 cases, spondylolysis in 3 cases, spondylolisthesis in 1 case, congenital defect of the lamina in 1 case, and lumbalization of the 1st sacral vertebra in 1 case. Pantopaque myelography appeared indicated in 7 patients to substantiate further the diagnosis of herniated nucleus pulposus.

or to rule out intravertebral canal pathology The test was suggestive of the former in 3 patients and negative in 4

FINDINGS AT SURGERY

At the time of operation, 25 of the 36 cases (69.4 per cent) had single disc lesions as follows Lumbar IV—3 patients, Lumbar V—22 patients Eleven of the 36 cases (30.6 per cent) had multiple disc lesions as follows Lumbar III and V—1 patient, Lumbar IV and V—9 cases, Lumbar V and VI—1 case

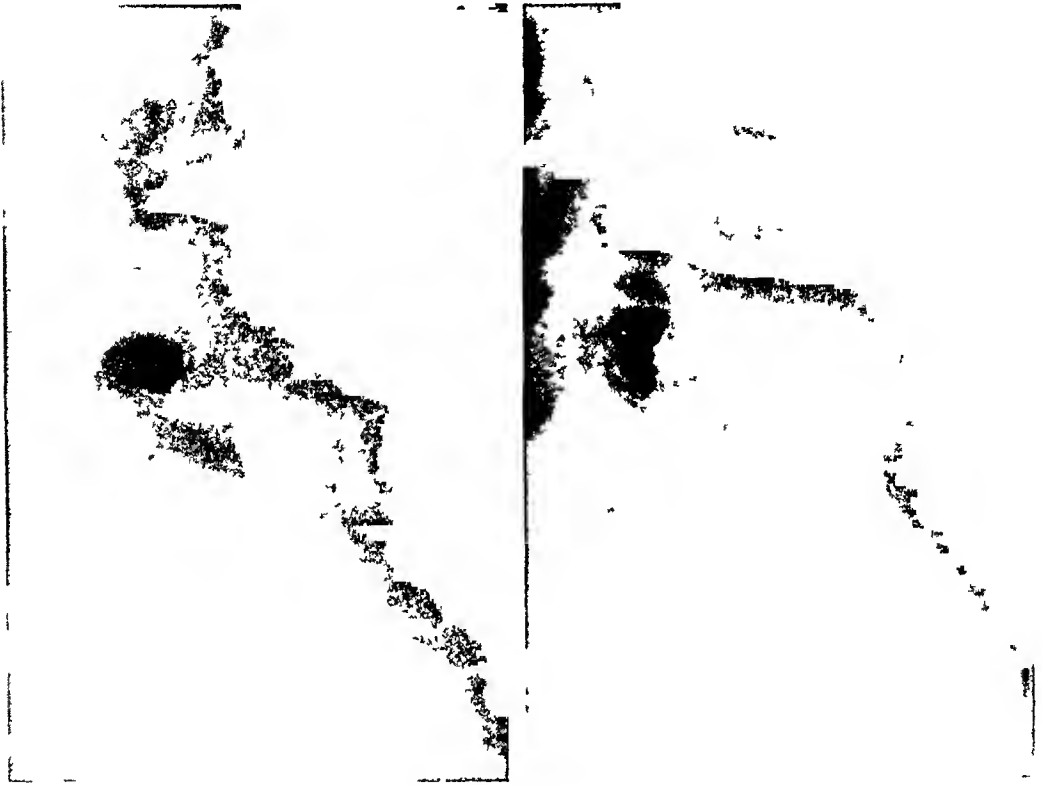


Fig 9—(a) Lat X-ray for position of bone implantation 30 days postoperative (b) Lat X-ray for progress 11 mos postoperative Fusion present

POSTOPERATIVE COMPLICATIONS

Postoperative complications occurred in 5 patients, or 14 per cent, as follows Phlebothrombosis (femoral vein) 2 cases (5.6 per cent), wound separation 1 case (2.8 per cent), hypostatic pneumonia 1 case (2.8 per cent), cystitis (acute) 1 case (2.8 per cent) Of the 2 cases of phlebothrombosis, 1 was of minor intensity and had no sequelae The other patient continues to have minor residual swelling of the involved extremity The postoperative wound separation occurred on the 11th postoperative day in a very obese and uncooperative patient Evisceration did not occur However, he developed a ventral hernia which has subsequently been repaired The hypostatic pneumonia occurred on the 5th postoperative day and was controlled within 48

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hours by chemotherapy. The patient had no sequelae. The complication of postoperative cystitis appeared on the 5th day of convalescence and was secondary to catheterization. Forced fluids and sulfadiazine controlled this complication within a period of three days.

RESULTS

Since the time of surgery, the patients have been followed as outlined previously. All cases, with one exception, have returned for monthly check-ups. This patient was last seen after his 4th postoperative month, at

TABLE I

		Back Symptoms	Leg Symptoms	Neurologic Findings	General Status	
					Cases	Percent Total
Less than 4 months (10 cases)	Unchanged	2	1	1	1	2.9 per cent
	Improved	8	1	1	9	25.7 per cent
	Asymptomatic	0	8	8	0	
4-8 months (14 cases)	Unchanged	0	0	0	0	
	Improved	13	8	4	13	37.0 per cent
	Asymptomatic	1	7	10	1	2.9 per cent
8-12 months (11 cases)	Unchanged	1	1	0	1	2.9 per cent
	Improved	4	2	4	5	14.3 per cent
	Asymptomatic	6	8	7	5	14.3 per cent
Total unchanged			5.8 per cent			
Total improved			77.0 per cent			
Total asymptomatic			17.2 per cent			

TABLE I—Tabulation of symptoms and general status of cases in postoperative periods from 1 to 4 mos—4 to 8 mos—and 8 to 12 mos

which time he was asymptomatic. Since he has subsequently been lost for follow-up examination, his case has been excluded from the result series.

Final results at the time of this writing are, of course, impossible to evaluate, since inadequate time has elapsed. Furthermore, the series is too small for statistical value. However, definite trends toward an ultimate result can be seen. For convenience of analysis the postoperative status of these cases has been divided into 4-month periods as follows:

Less than 4 months — 10 patients
4 to 8 months — 14 patients
8 to 12 months — 11 patients

Table I utilizes the above grouping and tabulates the status of the patients at the time of this writing. In brief, 2 or 5.8 per cent, of the 35 cases are unchanged, and 6, or 17.2 per cent, are asymptomatic. The remaining 27 cases, or 77 per cent, are improved. However, without exception in this improved group, residual symptoms and findings have decreased in intensity.

and frequency in direct relationship to the length of time from the date of surgery. This observation tends to indicate that eventually these patients will be classified as symptom-free. Generally the chart demonstrates that this complete recovery is slow. This is to be expected, since advanced bony fusion of the involved intervertebral joint is necessary before the patient becomes completely asymptomatic. This principle is substantiated in the roentgen-ray findings which are tabulated in Table 2. Those patients in whom there is demonstrated bony fusion by roentgen-ray are asymptomatic.

It has been found that bony callus appears in 3-4 months in some cases. Fusion is usually not seen by roentgenograms until the 8-12 month period.

TABLE II—*X-ray Findings*

Time Intervals	Callus Absent	Callus Present	Fusion Present
Less than 4 months (10 cases)	5	5	0
4-8 months (14 cases)	0	13	1
8-12 months	0	5	6
	—	—	—
	5	23	7

TABLE II—X-ray findings in postoperative cases indicating progress of fusion in the 4 mos. period of the 1st year

At the present time one case demonstrates early fusion in the 4-8 month group (Fig. 8). One of the cases in the 8-12 month group demonstrates fusion and is illustrated in Fig. 9.

All patients have been advised most conservatively in regard to returning to duty or work. It has been our feeling that definite harm to the softened bone graft and early callus might be produced by too strenuous activity. Though many patients have felt capable of performing duty after three months of convalescence, we have not recommended their return to work until there is adequate evidence of early fusion or advanced callus formation. Table 3 tabulates the work status of the 35 cases. As may be seen in the table, these patients do not return to duty until after the 4th month of convalescence. Fourteen patients or 40 per cent have returned to duty.

At this time, one of the 8-12 month group is considered as unsatisfactory. The patient's symptoms of back pain have not shown enough improvement for any rehabilitation, the sciatic symptoms are improved, and callus formation is present on roentgen-ray examination.

This procedure has been devised as an attempt to improve on some of the undesirable features of the posterior approach and the surgical treatment of symptoms caused by degeneration of the intervertebral disc. It is realized that meticulous care must be used to exclude other diseases and intra-spinal lesions before carrying out this procedure, although it gives excellent exposure to the disc, it does not allow for complete exploration of the spinal canal and cord. Further, it is our opinion that all clinical symptoms and physical findings should be carefully analyzed to localize the nerve roots and

disc spaces before surgery, thus effecting a better evaluation of the findings at operation with the preoperative symptoms. It is realized that as small a series of cases as is now presented will not be sufficient to make a definite evaluation as to its efficiency in treating degenerated discs. Neither is the duration of time that has elapsed since surgery sufficient to allow a final conclusion on this small series. However, we believe there are certain aspects in the principles applied and trends in the beneficial results so far obtained which make this publication worth while.

TABLE III—*Duty Status*

Time Interval	Off Duty	Light Duty	Full Duty
Less than 4 months (10 cases)	10	0	0
4-8 months (14 cases)	9	3	2
8-12 months (11 cases)	2	3	6
	—	—	—
	21	6	8
	(60 per cent)	(17.1 per cent)	(22.9 per cent)
	—	—	—
	21	6	8
	(60 per cent)	(17.1 per cent)	(22.9 per cent)

TABLE III—Duty status of postoperative cases, arranged in 4 mos periods during 1st year

CONCLUSIONS

- 1 A method of complete removal of either the 3rd, 4th, or 5th lumbar intervertebral disc, with technic to fuse the joint, is presented.
- 2 The principles and technic are outlined.
- 3 This procedure has been used since February 27, 1946, in 36 cases of herniated intervertebral discs. Postoperative complications have occurred in five patients. There have been no deaths.
- 4 A preliminary survey of monthly follow-up studies on 35 of the 36 postoperative cases reveals six cases asymptomatic, 27 improved, and two unchanged. The course of improved cases is toward complete recovery from symptoms existing prior to surgery. Fourteen patients have resumed either light or regular duty.
- 5 The obliteration of the involved disc space by bony fusion is necessary for complete amelioration of symptoms.

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A SIMULTANEOUS ABDOMINAL AND PERINEAL APPROACH IN OPERATIONS FOR IMPERFORATE ANUS WITH ATRESIA OF THE RECTUM AND RECTOSIGMOID

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THERE IS A SMALL GROUP of patients with imperforate anus which presents difficult surgical problems because the large bowel is absent or has no lumen from a point within the peritoneal cavity to the anal dimple so that it cannot be reached satisfactorily from the perineum. These cases correspond to Type III of the Ladd and Gross¹ classification.

In two such patients in whom the sigmoid, as outlined by roentgen ray, stopped at a point about half-way between the anal dimple and the umbilicus, we have carried out a one-stage abdomino-perineal procedure working through both perineal and abdominal incisions at the same time. We believe the simultaneous approach has certain advantages which may help to make the one-stage operation feasible.

The mortality in the two-stage procedure, as reported by five authors,^{1, 2, 3, 4, 5} has been discouragingly high, and in the single case in which a one-stage abdomino-perineal operation was reported the patient died. We presume that this operation was done along the conventional lines used for resection of rectosigmoid carcinoma in adults, that is, the abdominal stage was completed first and then the perineal stage was carried out (Table I), but no details were given.

Brief case reports of these two infants are as follows.

Case 1—H L, a 6-pound, 9-ounce male baby 24 hours old, was admitted to the Hospital of the University of Pennsylvania on August 19, 1944. Physical examination showed only a small dimple in the anal region and was otherwise negative. Roentgen-ray examination by the Wangenstein-Rice⁶ method showed gas in the colon approximately 45 cm from the anal dimple. The child was operated upon under open drop ether the same day. The skin was prepared from the clavicles to the toes and the child was placed on a sterile sheet. A perineal approach was first attempted, but the bowel could not be reached from below. The abdomen was then opened through a low left rectus incision. The lower end of the large bowel was found to be bound down tightly to the posterior abdominal wall. The lateral peritoneal folds were divided and the bowel freed. With the fingers of one hand in the perineal wound and the other hand in the pelvis through the abdominal incision, an opening was made from the pelvis to the perineum. The bowel was then guided bimanually down through the perineum and 50 centimeters of the distal portion of the large bowel exteriorized. The abdominal wound was then closed. The portion of bowel exteriorized was opened and a No. 24 F soft rubber catheter inserted. The bowel was then closed around the catheter. On the third post-operative day the exteriorized bowel was excised and the edges of the bowel sutured to the perineum.

After operation the baby was maintained with parenteral fluids for 48 hours. On the third postoperative day a skim milk formula was instituted. On the sixth postoperative day the baby had its first normal bowel movement.

IMPERFORATE ANUS

The subsequent course of this patient was disappointing. Although the intestinal tract functioned satisfactorily, the child did not gain properly, and it was found that the blood urea nitrogen was elevated. After three months the child finally died on December 30, 1944, apparently in uremia. Autopsy revealed bilateral hydro-ureter and hydro-

TABLE I—*The Mortality of Two-Stage Operations for Imperforate Anus (Type III of Ladd and Gross)*

Author	No of Cases	Mortality %
Berman (2)	2	50
Quinland (3)	5	100
Fitchet (4)	10	80
Helwig (5).	3	100
Ladd and Gross*	43	72

* Ladd and Gross' report 1 case of a one stage abdomino-perineal repair which was unsuccessful

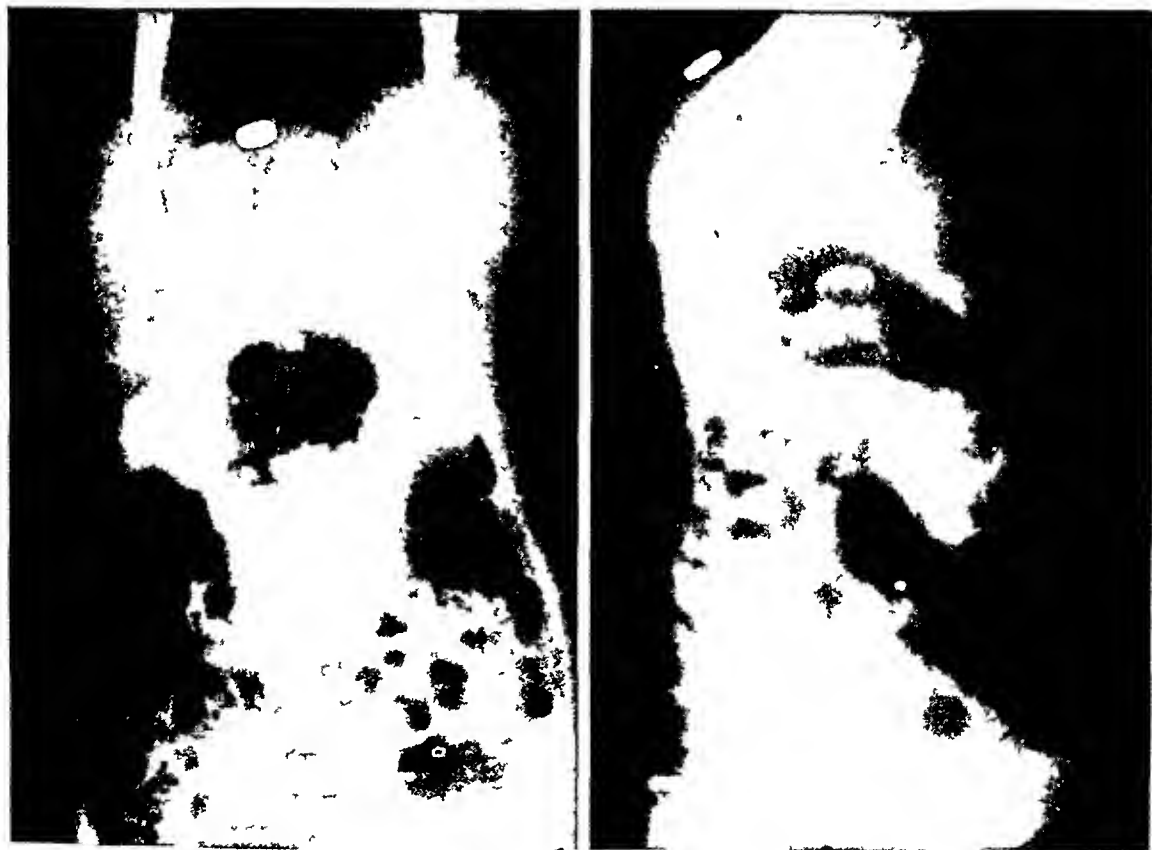


FIG 1—Anteroposterior and lateral roentgenograms of J D (Case 2) before operation obtained by the method of Wangenstein and Rice⁶

nephrosis, but there was no evidence at autopsy that the ureters had been damaged at operation. It was thought at one time early in the patient's course that there was a urethral fistula in the perineum, but no evidence of this could be found at autopsy, and the obstruction appeared to be at the lower ends of the ureters.

Case 2—J D, a 5-pound, 12½-ounce male infant, was admitted to the Hospital of the University of Pennsylvania when 24 hours old with a diagnosis of imperforate anus. Physical examination revealed a small dimple where the anus should have been and a

slight hypospadias The infant was in good condition with no evidence of dehydration Roentgen-ray by the Wangenstein-Rice⁶ method revealed a distance of approximately 70 centimeters between the anal dimple and the distal end of the descending colon (Fig 1)



FIG 2—J D (Case 2) Position of the patient on the operating table showing both the abdominal and perineal incisions The entire skin surface from the axillae down was prepared The in dwelling urethral catheter is shown Moderately distended bowel is seen in the abdominal incision

FIG 3—J D (Case 2) The anterior wound completely healed just prior to discharge from the hospital

A combined one-stage abdominoperineal repair as described in Case 1 was carried out, the only difference in the technic being that a small catheter was placed in the bladder to aid in preventing injury to the urethra at the time of operation (Fig 2)

Postoperatively the infant did well, and in 36 hours was maintaining fluid balance orally. The infant remained in the hospital 29 days. At the time of discharge the infant was on an evaporated milk formula suitable for a child of this age. The perineal colostomy was functioning well. His weight at the time of discharge was 7 pounds, 0.5 ounce. Figures 2 and 3 show the wounds shortly before he left the hospital.

At two and a half months of age, the child weighed 12 pounds, 8 ounces, and the perineal colostomy continued to function well. At the age of eight months the weight was 18 pounds, and the child appeared healthy.

DISCUSSION

Lee⁷ has commented on the frequency with which other abnormalities, particularly those of the urinary tract, are associated with imperforate anus.



FIG 4—J D (Case 2) The posterior wound just prior to discharge from the hospital. There is still a little redundancy of the mucosa and a small amount of granulation tissue is present. The absence of sphincter control permits frequent small evacuations which have resulted in some skin irritation in spite of frequent changing of diapers. The irritation has never become severe.

As far as the pathologist could determine at autopsy, the hydro-ureters, which developed in the first case, were not the result of the operative interference but were a congenital abnormality. We felt that the survival time of three months was sufficient to indicate the safety of the operation unless there was evidence that the operative procedure was responsible for the disease of the urinary tract.

The prognosis of patients, such as the two described, will always be determined largely by the supportive treatment which they receive, and it may well be that the survival of these infants was due more to improvements in the supportive treatment than to any inherent factors in the operative procedure itself. Nevertheless, since statistics collected from the literature show that

colostomy alone has been an unsatisfactory procedure in infants with imperforate anus, we see certain advantages in the approach which was used in these two patients. First, in a certain number of the cases one would be successful in exteriorizing the bowel through the perineal wound before opening it. Second, if, through necessity or accident the bowel was opened in the peritoneal cavity, the meconium would probably still be sterile and the danger of peritonitis correspondingly less than it would be at the time of the second stage of the two-stage procedure. By doing the procedure all in one stage one does not face the possibility that the patient in whom a two-stage operation is planned will fail to improve sufficiently to permit the second stage of the operation.

CONCLUSIONS

A one-stage abdomino-perineal operation is suggested for certain cases of imperforate anus in which the colon cannot be reached safely from the perineum. The operation is facilitated by preparing the skin of the entire baby from the axillae to the toes so that the two approaches can be used simultaneously.

Two cases are reported, one child surviving three months at which time he succumbed with uremia and the other surviving and healthy at eight months of age.

The authors are indebted to Dr. A. V. Dapena for the pathological examination of H. L. (Case 1).

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ACUTE PANCREATITIS*

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THE PRIMARY PURPOSE of this paper is to present our experiences with acute pancreatitis at St Vincent's Hospital in the ten years between 1936 and 1946

Acute pancreatitis is not entirely a specific diagnosis so we decided to include in our analysis only those cases which had a sudden acute clinical onset, with diagnosis confirmed either by markedly elevated blood amylase, operation or autopsy. In the cases operated upon or subjected to autopsy we included only those showing marked edema of the entire gland without rupture or a rupture of the gland with fat necrosis and bloody exudate. This cut down the number of our cases to 30, an average of three a year.

Before discussing the findings in these cases we would like to have a brief review of the subject in general.

The internal secretion of the pancreas is mainly insulin. The external secretion is (1) coagulable protein, (2) inorganic constituents, and (3) three enzymes—(a) trypsin proteolytic, (b) amylase (pancreatic diastase) amylolytic, and (c) lipase (lipolytic).

We are particularly interested in amylase because in acute pancreatitis there is a temporary diffusion of amylase in the blood. Amylase is also found in small amounts in urine, lymph, feces and milk.

Seventy to 200 milligrams of sugar will normally be formed by the action of 100 cc of blood. Values above 200 or below 60 are distinctly abnormal. Marked elevations of blood amylase from 500 units to as high as 3,000 are almost always found in the acute cases of pancreatitis, as defined previously. The peak is reached usually in 12 to 24 hours, but occasionally as late as 48 hours. After the peak there is usually a precipitous but occasionally a gradual fall to the normal level in two to six days after onset.

The absence of such an increase in serum amylase within the first six to 24 hours after the onset of acute symptoms almost certainly excludes the possibility of acute pancreatitis as the cause of the symptoms. This is not true after 48 hours. Serum lipase determinations are also very reliable but have not been so commonly used. After the initial rise the subsequent fall is more gradual than with serum amylase. In acute pancreatitis, urine values rise shortly after those in the blood. Hyperglycemia and diminished glucose tolerance occur in about 50 per cent of acute pancreatitis and glycosuria in 10 to 15 per cent.

The above brief summary of the physiologic chemistry involved in acute pancreatitis was taken from Canterow and Trumpe, *Chemical Biochemistry*¹. The laboratory data in our cases is not complete so we are not able to quote percentages, only the individual findings.

* Read before the New York Surgical Society, February 5, 1947

TABLE I

SERIES 30 CASES—ACUTE PANCREATITIS

Case No Ad Diag	Sex	Age	Nat	Predisp Causes	Epig Pain	Shock	Dysp	Adm Temp	Nausea Vomit	Cyan	W & D BI Amyl	P X	Treatment	Result
B14363 Perf duod ulcer	F—W 5-45	51	German	Indigestion 3 years	Severe	0	0	97.4	Nausea Vomiting	0	28 000 80% polys S A 243	Acute abd	Expl lap, no drain	Disch 11th P O day
31852 Acute appen 33639	F—W 6-47	50	Not stated	No record	Sev post pran 1 year	0	0	101	Nausea Vomiting	0	14,000 81% polys S A None	Acute abd	Pancreato- tomv, with drainage	Dis 89 P O day—compl thrombophl
Perf ulcer	M—W 10-37	34	Not stated	No record	Sev 4 hr prior to admis	0	0	99.4	Nausea Vomiting	0	14 000 89% polys S A None	Acute abd	Cholecys- tostomy	Disch 26 P O day
22174 Perf ulcer	M—W 7-36	42	Not stated	Chronic alcoholism	Severe	0	0	99.4	Nausea Vomiting	0	None	Acute abd	Pancreatotomy	Disch
33052 Acute appen	M—W 10-37	32	Irish	No record	General abdom pain	0	0	101	Nausea Vomiting	0	16 000 87% polys S A None	Acute abd	Pancreato- tomy	25 P O day
32174 Perf ulcer	F—W 9-37	59	Not stated	Vague abd pain 2 years	Severe	0	0	99.4	Nausea Vomiting	0	29 000 89% polys S A None	Acute abd	Pancreato- tomy	Died at operation
37745 Perf ulcer	M—W 4-38	53	Hungarian	Indiscretion fatty foods	Severe on admis	0	0	103	Nausea Vomiting	0	12 400 88% polys S A None	Acute abd	Cholecysto- tomy— Pancreatotomy	Died 7th H D
36376 Acute paner	M—W 12-37	47	Italian	Indigestion 6 mos	Severe epig P	0	0	98	Nausea Vomiting	0	11 160 90% polys S A None	Acute abd	Expl lap, with drain	Disch 27 P O day
33483 Acute paner	M—W 11-37	56	German	Not recorded	Severe epig pain	0	0	100.4	Nausea Vomiting	0	14 610 80% polys S A None	Acute abd	Pancreato- tomy Chole- cystostomy	Died 66 P O day—cr st.
7857 Acute paner	F—W 10-34	54	Spanish	Obese	Severe epig P	0	0	97	Nausea Vomiting	0	15 700 90% polys S A None	Acute abd	Supportive	Died 3rd H D no autopsy
24092 ?	M—W 6-36	31	?	Abd cramp 6 mos	Epig pain	0	0	98.4	Nausea Vomiting	0	24 600 89% polys S A None	Acute abd	Cholecystos- tomy	Disch 26 P O day
29093 ?	M—W 6-42	44	?	Ob jaund Indiscretion Fatty foods	Epig pain	+	0	98	Nausea Vomiting	0	15 200 90% polys S A 3440	Acute abd	Pancreatotomy	Disch 105 P O day
No ? Coroma occlus	M—W 25-46	64	Jewish	Obese	Epig pain	+	+	98.6	Nausea Vomiting	+	17 200 88% polys S A 275	Acute abd	Cholecystos- tomy	Died 20 P O day
B9689 Acute chol	M—W 10-44	47	Italian	Obese, G B	Epig pain	0	0	99.2	Nausea Vomiting	0	16,000 85% polys S A 411	Acute abd	Miller Abbott IV fluids	Died 7 P O - Autop
B4337 Ac chol	M—W 10-44	49	Slav	Dyspcpala for years	Epig pain	0	0	101.6	Nausea Vomiting	0	20,000 76% polys S A None	Acute abd	Supportive	Ac pan Disch 17—H D
													Expl lap 18—H D Fat necro	Disch 30 H D

ACUTE PANCREATITIS

TABLE I—(Continued)

SERIES 30 CASES—ACUTE PANCREATITIS

Case No Ad Diag	Sex	Age	Nat	Predis- posing Causes	Epig Pain	Shock	Dysp	Adm Temp	Nausea Vomit	Cyan	W & D Bl Amyl	P X	Treatment	Result
2501 Acute append	F—W 27-44	65	Polish	Obese	Severe on admis	0	0	98 6	Nausea. Vomiting	0	W & D— none S A 207	Acute abd	Cholecystec- tomy Cholecho- stomy	Disch 45 H D
2373 Acute append	F—W 2-44	57	?	Obese	Severe on admis	0	0	100 8	Nausea Vomiting	0	29,200 86% polys S A None	Acute abd	Chole- do- stomy	Disch 21 H D
32957 Peritonitis?	M—W 10-42	40	Irish	Known duodenal ulcer	Severe on admis	0	0	104	Nausea Vomiting	0	10,300 82% polys S A None	Acute abd	Drainage of pancreas	Died 2nd P O day
816 Perf ulcer	M—W 12-43	46	Italian	Epig pain 4 mos	Severe on admis	0	0	101	Nausea Vomiting	0	8,000 82% polys S A None	Acute abd	Expl lap, no drain	Disch 17th H D
5169 Acute pancr	M—W 4-44	20	Jewish	Obese	Severe	0	0	101	Nausea Vomiting	0	10,700 73% polys S A 311	Acute abd	Cholecys- tectomy	Disch 39 P O day
16910 Perf ulcer	M—W 8-40	75	Irish	Indigestion 1 year	General abd pain	0	0	99 6	Nausea Vomiting	0	14,200 80% polys S A 643	Acute abd	Expl lap Pancreato- tomy	Died 16 H D aut Ac Pan
A-16235 Acute chole	F—W 10-40	69	Irish	Obese	Epig pain	0	0	99 8	Nausea Vomiting	0	15,250 96% polys S A None	Acute epig pain, with rebound	Expl lap Pancreato Supportive	Died 4th H D aut Ac Pan Disch 19th H D
27623 Acute chole	M—W 4-24	52	Swede	Indigestion Obese	Epig pain	0	0	100 4	Nausea Vomiting	0	15,150 87% polys S A 795	Acute abd	Expl lap, with drain	Died 28 H D autop Ac Pan
A-39085 Acute chole	M—W 5-43	55	Irish	Indigestion Obese	Epig pain	0	0	102 4	Nausea Vomiting	0	19,650 80% polys S A None	Acute abd	Expl lap, with drain	Died 3rd H D aut Ac Pan
17024 Acute append	M—W 11-40	39	Irish	Chronic alcoholic	Epig pain	0	0	98 6	Nausea Vomiting	0	10,500 82% polys S A None	Acute abd	Supportive Bl trans	Disch 24 H D
16330 Twisted ovarian cyst	F—W 9-40	41	Italian	Epig pain 2 mos Obese	Epig pain	Acute	+	98 6	Nausea Vomiting	0	40,200 73% polys S A 900	General abd pain	Supportive	Died 1st H D AP
16898 Cerebral acc	F—W 1-43	47	Italian	Obese Jaundice 2 wks and rex	0	0	0	99 6	Nausea Vomiting	0	14,700 88% polys S A 474U	Acute abd	Supportive	Died 1st H D
44363 Gastro- enter	M—W 12-43	32	?	Chronic alcoholic	Epig pain	0	0	98 6	Nausea Vomiting	0	4,600 52% polys S A 200U	Acute abd	Expl lap, with drain	Transfer
29722 Inteat ob	M—W 7-42	33	Polish	Constipation Abd disten	Epig pain	0	0	98 6	Nausea Vomiting	0				

TABLE II
SPECIAL CASE

Case No	Sex	Age	Nat	Predisposing Cause	Epig Pain	Shock	Dysp	Adm Temp	Nausea Vomiting	Cyan	W & D Bl Amyl	P X	Treatment	Result
Adm Diag 29875	M	39	Chinese	Indiscretion Fatty foods RUQ dist	None	0	0	99	Nausea Vomiting	0	None	Acute abdomen	Cholecystectomy (empyema)	Disch 33rd H D
Re ad	8-42				Acute epig pain	Acute shock	+	97 6	Nausea Vomiting	0	None	Board-like abdomen	Exp lap Acute hemorrhagic pain with fat necrosis	Disch 16 H D
Re ad	7-43				Acute epig pain—radiates to back	0	0	98	Nausea Vomiting	0	S A 377	Acute abdomen	Supportive	Disch 5th H D
Re ad	9-43				Epig pain	0	0	100	Nausea Vomiting	0	S A 663	Acute abdomen	Supportive	Disch 9th H D
Re ad	10-43				Epig pain	0	0	99 6	Nausea Vomiting	0	S A 522	Acute abdomen	Supportive	Disch 7th H D
Re-ad	7-28-44				Epig pain	0	0	100	Nausea Vomiting	0	S A 900 15,200 78% polys	Acute abdomen	Supportive	Disch 6th H D

ACUTE PANCREATITIS

ETIOLOGY

Fitts, of Boston, in 1889, published the first clear-cut pathologic and clinical description of acute hemorrhagic pancreatitis. The etiology, however, is still undetermined. Trauma, vascular injury, infection and bile invasion of the pancreatic ducts are all factors.

About two years ago John Morton,² in his paper published in *Surgery*, had a very complete bibliography on this whole subject, with particular references to Somogyi's³ contribution to diagnosis in 1938, when the simple method of amylase determination was developed. In connection with pathology, however, he placed great importance on the differentiation between acute edematous pancreatitis and acute necrosis, a differentiation which affects treatment. Where

TABLE III
MORTALITY PERCENTAGE—NO OPERATIONS

Total Cases		7		Recovery		3		Died		4	
Choledo- chostomy		Expl Lap with Drain		Pancreato- tomy		Cholecystostomy with Pancrea- totomy		Cholecystectomy with Choledo- chostomy		Cholecys- tectomy	
Cases	1	Cases	7	Cases	5	Cases	5	Cases	2	Cases	3
Recovered	1	Recovered	5	Recovered	4	Recovered	2	Recovered	2	Recovered	3
Died	0	Died	2	Died	1	Died	3	Died	0	Died	0
Total Operated Cases									23		
Recoveries									17		
Deaths									6		
Total Females									9		
Total Males									21		
Average Age									47.5		
P. H. Gallbladder disease									15		
P. H. Obesity									11		
P. H. Alcoholism									3		

the diagnosis of edema without necrosis was made 29 cases not operated upon all recovered. In 27 cases where pancreatic necrosis was diagnosed or discovered, 19 died—ten with operation and nine without operation. He does not, however, make clear how the diagnosis between edema and necrosis is made except by the fact that the cases of edema improved and the cases with necrosis did not. He feels the cases with necrosis should be operated upon for drainage if nothing else. The cases of necrosis are more prostrating at the start, but this is a matter of degree of symptoms.

All of us who have been on call for emergency surgery in an acute hospital have tried to keep in mind the diagnosis of acute pancreatitis in any sudden abdominal crisis, and still, strangely enough, the diagnosis was rarely made before operation until the advent of amylase determination. The clinical picture varies, and we cannot do better than quote three personal experiences of T. M. Furber,⁴ of Sydney, Australia, as follows:

"I well remember a man at Sydney Hospital who, while waiting in Dr. Hamilton Marshall's out-patient department, fell from his seat, laboring under what Lord Moynihan has so aptly called, 'illimitable agony.' It was evident even to such mole-eyed students as we were that the unfortunate old man was stricken unto death, as he quickly became a dreadful, livid, ashen hue, and writhed and groaned in a calamity of pain, fighting for

breath and calling on our Maker for help in what was truly his last extremity. Some three days later he died, as was discovered at autopsy, of pancreatic necrosis.

"Another picture which comes to mind is that of a decent, middle-aged widow, who lived virtuously alone, with gallstones, which for years, in spite of advice, she had harbored and, I think, cherished. Soon after dinner one night she was overwhelmed by an abdominal cataclysm. When I saw her a few hours later she was sitting up in the middle of a big double bed, slowly rocking herself back and forth and gently moaning, but not taking the slightest notice of the bewildered females who clucked and fluttered around her, nor answering direct questions, for her sensorium was apparently saturated by the

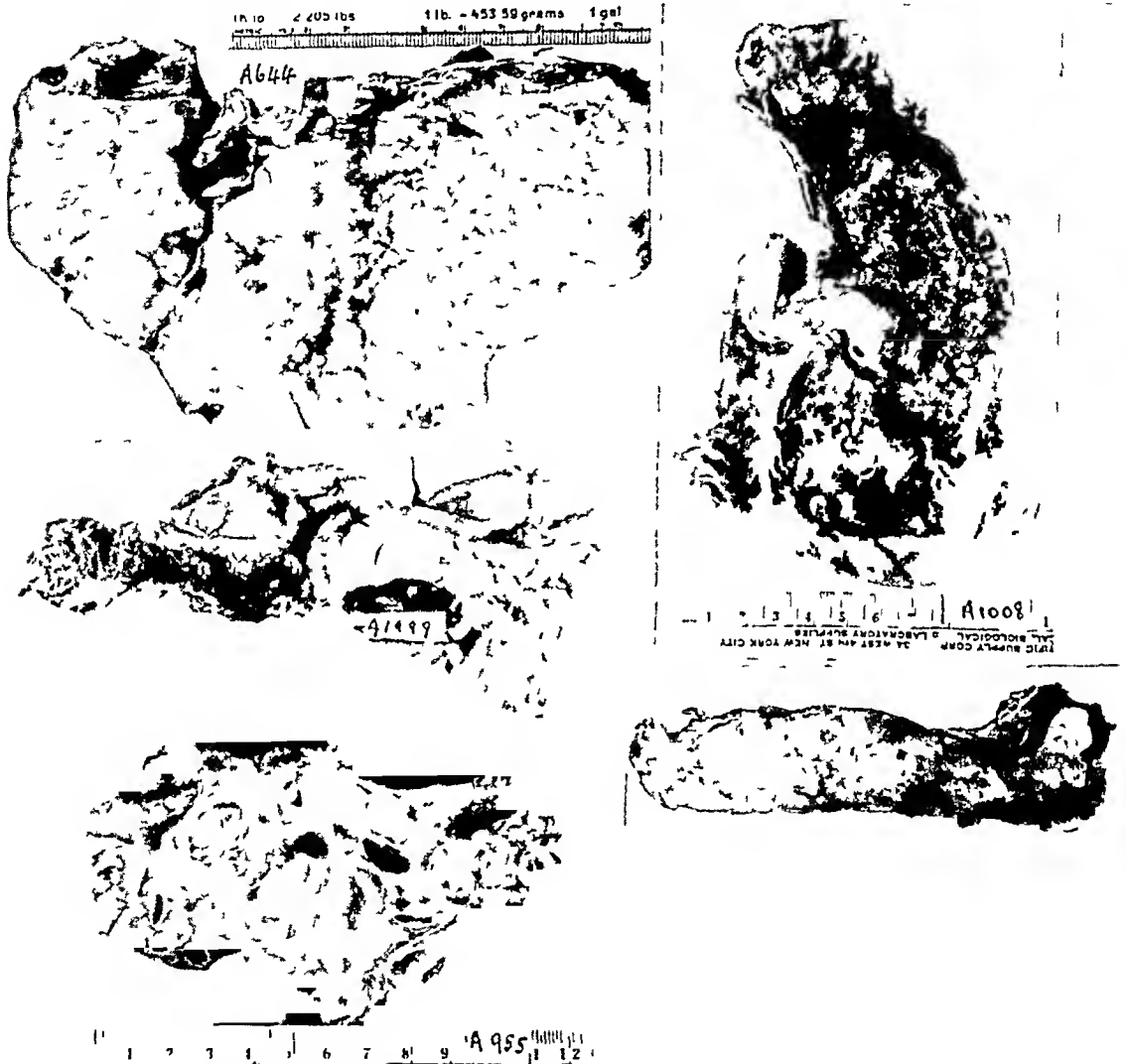


FIG 1—Photographs of five gross specimens of Acute pancreatitis removed at autopsy

tremendous discharge of afferent stimuli from her abdomen. Knowing that she had gallstones, I guessed that she had acute pancreatitis, and advised her immediate removal to the hospital, but while arrangements were being made her tempestuous daughter burst in on us like a southerly gale and whisked the unfortunate old lady to her own home, where the poor soul perished of what was proved, at the coroner's autopsy, to be pancreatic necrosis.

"Fortune seemed to smile on a sprightly, brisk, young bachelor when he won the lottery. He at once gave up his uninteresting and comparatively unremunerative toil for what was, for him, the more congenial task of helping the brewery proprietors to issue a few more bonus shares. He succeeded so well in this, no doubt, laudable crusade that for a month or more he was seldom sober, and thought he was having a wonderful time, till

suddenly the Grim Reaper breathed on his pancreas and it died, and so did its owner within three days. He, unlike the other two, lay as still as a mouse or as a patient with a ruptured peptic ulcer. The metabolic revolution had caused such profound shock that, as Professor Wilson used to say 'It was patent to the meanest intelligence' that the poor fellow was destined soon to find out whether the story of Saint Peter and the Digger had any truth in it. Resuscitatory treatment did not reclaim him, and he died without operation. Autopsy revealed hemorrhagic pancreatitis."

It is difficult to add to this complete and dramatic clinical description, but there are three features which have impressed me in differentiating this condition from a perforated ulcer (1) Shock, which is usually absent in ulcer (2) Rigidity more or less confined to the upper abdomen and not diffuse as in ulcer (3) Occasional cyanosis

Tables I and II represent the summary of cases from the surgical service at St Vincent's Hospital, selected as explained in the opening paragraph (Table II is on a special case). In Table III certain features deserve emphasis. The predominance of males over females—21 to 9—is just reverse of the findings in other series, also, strangely enough, the operative cases had a lower mortality than the nonoperative cases. Pancreatotomy, which is distinctly contraindicated, had a mortality of only 20 per cent. Fifteen cases gave a previous history of gallbladder disease. This seems to be in line with previous reports. To have significance, however, the mortality statistics should be broken down into pathologic groups. This we have not been able to do in this series. The five photographs were taken at autopsies on cases included in this review, and were taken by our pathologist, Dr. Rottino.

Many gaps in the clinical data are obvious in this statistical review. It is too bad we can not plan these analyses ahead rather than doing them in retrospect. Under conservative treatment abscesses not infrequently form at the end of a week or ten days, which, upon drainage, discharge large amounts of foul-smelling material, somewhat like rancid curds of milk.

This sequela has a very definite mortality of its own. When the diagnosis of acute pancreatitis is made operation should be deferred, but it is a question whether delayed operation seriously affects the mortality. I am convinced that in some cases cholecystostomy and drainage of the lesser sac are distinctly beneficial. Pancreatotomy should never be undertaken, it provides no real drainage and may lead to disastrous hemorrhage.

CONCLUSIONS

- 1 Amylase readings are essential to the diagnosis of acute pancreatitis
- 2 The edematous type should not be operated upon
- 3 The necrotic type should be operated upon after the initial shock subsides
- 4 The clinical distinction between the two types is not easily made

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BURSITIS UNDER FIBULAR COLLATERAL LIGAMENT

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THE PURPOSE OF THIS PAPER IS to present six cases of chronically inflamed bursae found under the fibular collateral ligament of the knee joint Voshell and Brantigan demonstrated such a lesion in the region of the tibial collateral ligament and Hendryson recently reported six cases of bursitis of the fibular collateral ligament Cystic masses at the level of the knee joint line along the outer aspect are prone to be associated with cystic degeneration of the external meniscus However, careful dissection of these lesions and microscopic studies reveal that some of these masses are in no way related to the meniscus but are nothing more than chronically inflamed bursae Piersol describes two bursae in this region, one found between the fibular collateral ligament and the tendon of the popliteus muscle, and the second, lies between the fibular collateral ligament and the tendon of the biceps femoris He further describes the possibility of a bursa at the point where the tendon of the popliteus muscle merges at its insertion with the capsule of the knee joint It is at this point that these painful masses are located, and one may readily conclude that the painful cystic masses described by Hendryson and the six reported in this paper may be traumatized hypertrophic bursae which are normally found in this area

CLINICAL PICTURE

The lesion is usually found in the male sex Age is of no significance for in this small group the age range was from 16 years to 42 years Usually there is a history of trauma, however, in one case reported no such history could be obtained Repeated mild traumata undoubtedly is a definite causative factor Pain and the presence of a mass on the outer aspect of the joint are constant findings The pain is aggravated by walking, standing, and exercising In some instances the pain is more severe at night The mass, always present, may appear smaller at one time and larger at another The patient also has a feeling of "tightness" within the knee joint In no case was there diffuse swelling of the joint or a history of locking or instability of the knee joint The duration of the symptoms was from six months to three years

Physical examination usually reveals a small, tense, round, cystic mass from 1½ cm to 3 cm on the anterior aspect of the fibular collateral ligament at the level of the knee joint line The mass seems to dip beneath the anterior border of the ligament The mass fails to disappear upon pressure with the knee flexed It becomes more tense upon extension of the joint and upon hyperextension pain is greatly intensified Pain and tenderness is elicited by direct pressure over the lesion and upon adduction of the tibia on the femur

Occasionally there may not be a distinct mass present, as in Case II In this instance no circumscribed mass was present but the fibular ligament

appeared to be distended at the level of the joint space and palpation of this area revealed a tumefaction of the underlying tissues. Pressure elicited tenderness, and hyperextension produced exquisite pain. The tumefaction failed to disappear upon flexion of the knee joint.

CASE REPORTS

Case 1—E H, male, age 42. The patient had pain in the outer aspect of the right knee for six months. There was no history of trauma. The pain had an insidious onset and was becoming progressively more severe. He was conscious of a feeling of "tightness" on the outer aspect of the knee joint. Within the last month the pain was worse at night and aggravated by standing and walking. He gave no history of locking or instability of the joint.

Physical examination revealed a circumscribed mass $1\frac{1}{2}$ by 3 cm anterior to the fibular collateral ligament at the joint line. One-third of the mass dipped beneath the anterior margin of the ligament. The mass failed to disappear or decrease in size upon flexion of the knee joint, upon extension the mass became more tense and extension and hyper-extension of the joint elicited pain, adduction of the tibia, as well as direct pressure over the lesion, also produced severe pain. Roentgen-ray examination was negative for evidence of bone pathology. A diagnosis of bursitis was made.

At operation a mass $1\frac{1}{2}$ by 3 cm was found lying anterior to, and under, the anterior margin of the fibular collateral ligament. It was dissected out in toto without opening the joint cavity. There was no connection between the mass and the external meniscus. It was, however, loosely attached to the capsule of the joint. The patient made an uneventful recovery and was completely relieved of all symptoms.

Case 2—P P, male, age 17. The patient had a painful swelling on the outer aspect of the left knee for eight months. He gave a history of repeated traumata to the left knee joint during the previous football season. The pain was aggravated by walking and standing. He had no history of locking or instability of the joint.

Physical examination revealed a localized swelling on the outer aspect of the left knee joint. The swelling could not be defined by palpation, but the fibular collateral ligament was taut. The tumefaction did not disappear upon flexion of the knee joint. The pain was aggravated by extension and hyperextension of the joint, and by adduction of the tibia. Pressure over the area elicited marked tenderness. Roentgen-ray examination was negative for evidence of bone pathology. A diagnosis of bursitis was made.

At operation the mass was exposed by a longitudinal incision through the fibers of the fibular collateral ligament. Upon division of the fibers the mass herniated into the wound. The posterior surface was firmly adherent to the capsule of the knee joint. During the dissection the external meniscus was exposed. Inspection of the meniscus revealed no pathologic changes in this structure. The patient made an uneventful recovery and played football the following season.

Case 3—W Q, colored male, age 42. Three years prior to admission the patient was struck on the outer aspect of the left knee by a falling box weighing about 60 pounds. The knee became painful and swollen. He was treated by rest and a compression bandage. He noticed, after all swelling had subsided, a small mass on the outer aspect of the left knee joint which was painful on pressure and caused considerable discomfort at night. A diagnosis of a "cyst" was made and two attempts were made to remove the mass surgically. The mass reappeared after each surgical procedure. He was admitted to the Jefferson Hospital six months after the last operation complaining of a painful knee.

Physical examination revealed a large nodular mass on the outer aspect of the left knee. The mass seemed to disappear under the fibular collateral ligament. It was fixed to the underlying tissues and had a doughy feeling. Pressure over the mass elicited

tenderness. It failed to disappear upon flexion of the joint. Extension and hyperextension made the mass more tense and more painful. Roentgen-ray examination was essentially negative except for a soft tissue shadow cast by the mass outside the joint.

At operation the mass was exposed by a longitudinal incision. It was found immediately below the skin and appeared to dip beneath the lateral ligament. The part of the mass anterior to the ligament was readily delivered, but the posterior one third of the mass which lay beneath the ligament was delivered with great difficulty. It was necessary to divide some of the anterior fibers of the ligament in order to obtain an adequate exposure. The specimen measured 5 by $4\frac{1}{2}$ cm and was external to the joint capsule. The meniscus was not exposed.

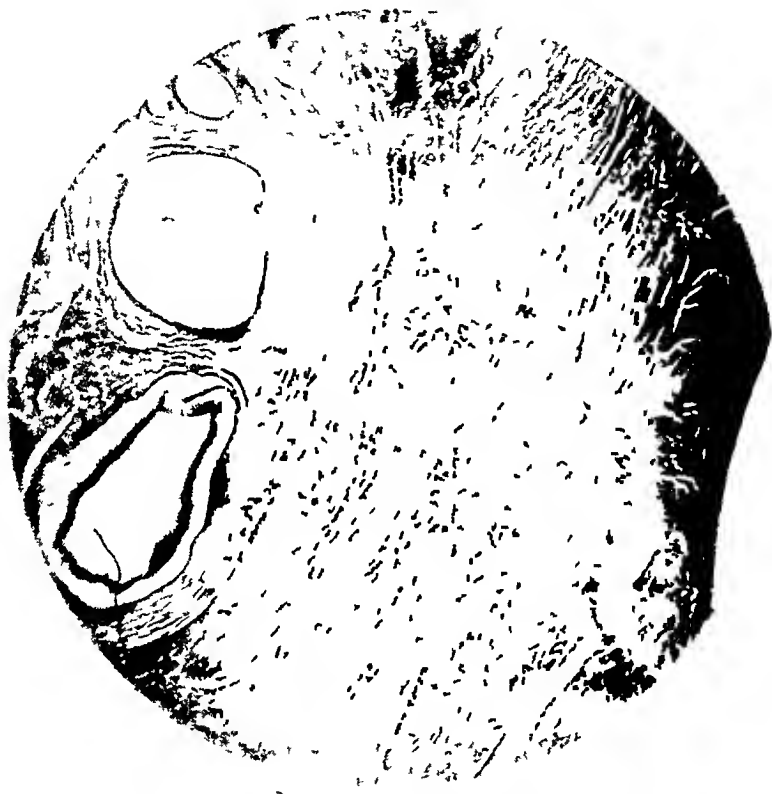


FIG 1—The microscopic section is typical of the histopathologic changes found in all six cases presented. Note the marked increase in fibrous tissue, and throughout there are many small cyst-like areas. These cysts have thickened fibrous tissue walls and are lined by a layer of flattened endothelial cells. The findings are consistent with chronic inflammation of a bursa.

Case 4—N. B., white, male, age 26. This 26-year-old veteran first injured his left knee two years ago when he struck the joint against the side of a jeep while getting into the vehicle. The joint became somewhat swollen and painful, but not enough to require hospitalization. About six months later he noticed a small mass on the outer aspect of the joint which was rather painful, more so at night. About that time he fell on the knee during maneuvers and this time his knee became so painful that he was hospitalized for three weeks before he was returned to duty. The painful mass persisted and within the past month he has been unable to walk without severe pain.

There was a mass $2\frac{1}{2}$ by 3 cm on the outer aspect of the left knee joint anterior to the fibular collateral ligament. Pressure over the mass elicited tenderness. The mass did not disappear on flexion of the joint. Extension and hyperextension aggravated the

pain and made the mass more tense. No limitation of motion of the joint was present, but both active and passive motion produced an audible "thump."

At operation a nodular mass was found under the skin which extended beneath the fibular ligament. It was so firmly adherent to the capsule that the capsule was removed with the mass and the periphery of the cartilage was exposed. The joint was explored and a discoid cartilage was found which was removed. Macroscopically no evidence of cystic degeneration was found in the cartilage. Microscopic sections of the meniscus also failed to reveal any cystic degenerative changes.

Case 5—A. C., white, male, age 28. This patient, an interne at the Jefferson Hospital, sustained several direct injuries to the outer aspect of the left knee while playing football two years prior to his present admission. He again injured the same knee during maneuvers while in the service. A diagnosis of a "cyst" was made and a mass was removed in an army hospital. He was free of symptoms until six months before admission to the hospital, when he again noticed a small mass on the outer aspect of the left knee. The mass became progressively larger and was very painful if inadvertently struck. His pain was constant, more severe at night; it was aggravated by standing and walking. The mass was aspirated on two occasions and a few cubic centimeters of a yellowish serous fluid were obtained each time. Following the aspiration some relief resulted and the mass diminished in size. However, it became distended and painful again within a few days.

Physical examination showed a round distended mass 2 by 2½ cm. on the lateral aspect of the left knee immediately under a three-inch vertical scar anterior to the fibular collateral ligament. The scar was firmly adherent to the underlying mass which was nodular and firmly attached to the underlying tissues. The posterior margin was not palpable, for it appeared to dip under the fibular ligament. Motion of the knee was not restricted. Extension and hyperextension of the joint made the mass more tense. Uniform pressure over the mass failed to reduce its size nor did it become smaller or disappear upon flexion of the joint.

At operation the old scar was resected and the mass was found so firmly attached to the capsule that a portion of the capsule was removed during the dissection, and the periphery of the meniscus was exposed. The cartilage appeared normal. No evidence of any cystic degeneration was found. In order to completely remove the tumor a second incision was necessary paralleling the posterior border of the fibular ligament. The mass was then readily delivered in toto from underneath the fibular collateral ligament.

Case 6—J. H., white, male, age 17. During the last high school football season the patient sustained repeated injuries to the left knee. Toward the end of the season he noted a small painful lump on the outer aspect of the joint. The mass became progressively larger and more painful. He was treated by a compression bandage. The mass became smaller but did not disappear. Within the past two months the knee had become very painful, especially when walking. The pain was worse at night. He was unable to find a comfortable position for his leg.

Physical examination revealed a small, rounded, smooth mass 1½ by 2 cm. on the outer aspect of the left knee joint anterior to the fibular collateral ligament. The mass was firm, lay immediately beneath the skin, and was firmly attached to the underlying tissues. Pressure elicited pain. The mass did not disappear when firm pressure was made upon it. Hyperextension of the joint increased the pain and made the mass more prominent.

At operation the mass was exposed by a small two-inch vertical incision and peeled off the capsule of the joint without exposing the meniscus. Its posterior border was found under the fibular ligament but it shelled out very readily after the ligament was retracted posteriorly. Section of the mass revealed that it was composed of several loculated areas which contained a thick colorless, jelly like substance.

REMARKS

It is of interest to note that in one case (Case 4) a discoid cartilage was present. Besides the painful mass present on the lateral aspect of the knee, a definite audible "thump" could be heard on active and passive flexion and extension of the knee. The cartilage could readily be felt, with each excursion of motion, to protrude beyond the articular margin of the outer tibial plateau. The forward displacement of the cartilage caused definite compression of the bursal sac for the mass became more tense and the tibular fibular ligament more taut.

It is obvious, in this instance, that the hyper-mobile discoid cartilage was the exciting factor in the formation of the cystic mass. The repeated traumata to the bursal sac resulted in a hyperplastic, thickened, loculated, chronically inflamed bursa.

Complete removal of the entire mass is essential in order to bring about a cure. In Cases 2 and 5 the mass recurred, following excision. Case 2 had had two previous excisions. Case 5 had had one previous excision. Frequently the bursa lies deep beneath the tibular fibular ligament and part of it may not be accessible because of the difficulty encountered in retracting the taut ligament sufficiently to give adequate exposure of the lesion. It may be necessary in such instances to split the tibular fibular ligament longitudinally in order to obtain access to the entire mass. On the other hand, it may be necessary to make a second incision parallel with the posterior border of the tibular fibular ligament and retract the ligament anteriorly in order completely to excise the mass.

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The Editors and the Publishers of the ANNALS OF SURGERY regret to announce the death of Dr. Roscoe R. Graham of Toronto, Canada on January 17, 1948. Doctor Graham served as a member of the Editorial Board for many years. His death will prove a great loss to the ANNALS OF SURGERY. A suitable memoir will appear in a later issue of the ANNALS.

TRAUMATIC ANEURYSM OF THE SUBSCAPULAR ARTERY*

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THE OCCURRENCE OF AN UNUSUAL arterial lesion among the large group of patients sustaining vascular injuries in World War II is not difficult to understand. Modern shells, which broke into innumerable small fragments travelling at high velocity, produced such an unprecedented number of vascular injuries that among them uncommon lesions can be expected. The only reports of subscapular aneurysm found in the literature are by Liston¹ in 1820 and McGraw² in 1865. Matas³ encountered none in his large series of aneurysms, and Makins⁴ collection of vascular injuries in World War I listed only two of the subscapular artery. Elkin⁵ has not included one in his publications from the Army Vascular Center. The rarity of the lesion is due to the anatomic location of the artery. The subscapular artery is a branch of the third portion of the axillary artery and lies on the subscapularis muscle in close association with the chest wall medially. A perforation of the artery in the distal two-thirds of its course would probably close spontaneously because the small fascial space would limit expansion of a blood clot, while in the proximal third, near its origin, an associated perforation of the axillary artery would be likely. An aneurysm of the subscapular artery can be expected to occur only when the artery is injured near its origin, without associated injury to the axillary vessels. The following case report describes such an occurrence.

CASE REPORT

C N, white, male, age 33, entered the Portland, Oregon Veterans Hospital on September 2, 1946. He had been hit in the right arm by a shell fragment in February, 1945, while in Germany. The wound of entrance was on the lateral surface of the arm in the mid-deltoid region. There was no wound of exit, the shell fragment lodging in the chest wall high in the axilla. There was considerable hemorrhage from the wound, which stopped with pressure. However, the entire right axilla and shoulder became markedly swollen and ecchymosis appeared extending to the elbow and onto the chest wall posteriorly in the scapular region and anteriorly to the sternum. The patient was evacuated to a general hospital in England where two massive hemorrhages from the external wound occurred on the 10th and 12th days following the initial injury. There was no further hemorrhage, the massive swelling of the shoulder decreased and the external wound closed. However, the patient noted a small circumscribed, firm swelling in the right axilla, which persisted and was present when he returned to civilian life. This axillary swelling gradually increased in size and became markedly enlarged during heavy work. It was associated with axillary pain, which radiated along the inner surface

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of the right arm and forearm to the wrist. The skin over the mass became red, tender and inflamed.

Physical Examination—Examination on admission revealed a tense, compressible, pulsating swelling in the right axilla, measuring 8 x 5 x 6 cm. There was no fremitus. Auscultation over the mass disclosed a soft, systolic bruit which disappeared on compression of the right subclavian artery. The right and left radial pulses were equal in volume and no dilatation of the veins of the right arm or forearm was present. The blood pressure was equal in both upper extremities: systolic 132, diastolic 80. Obliteration of the aneurysm caused no elevation in blood pressure or slowing of the pulse rate. A teleoroentgenogram of the heart showed no enlargement.

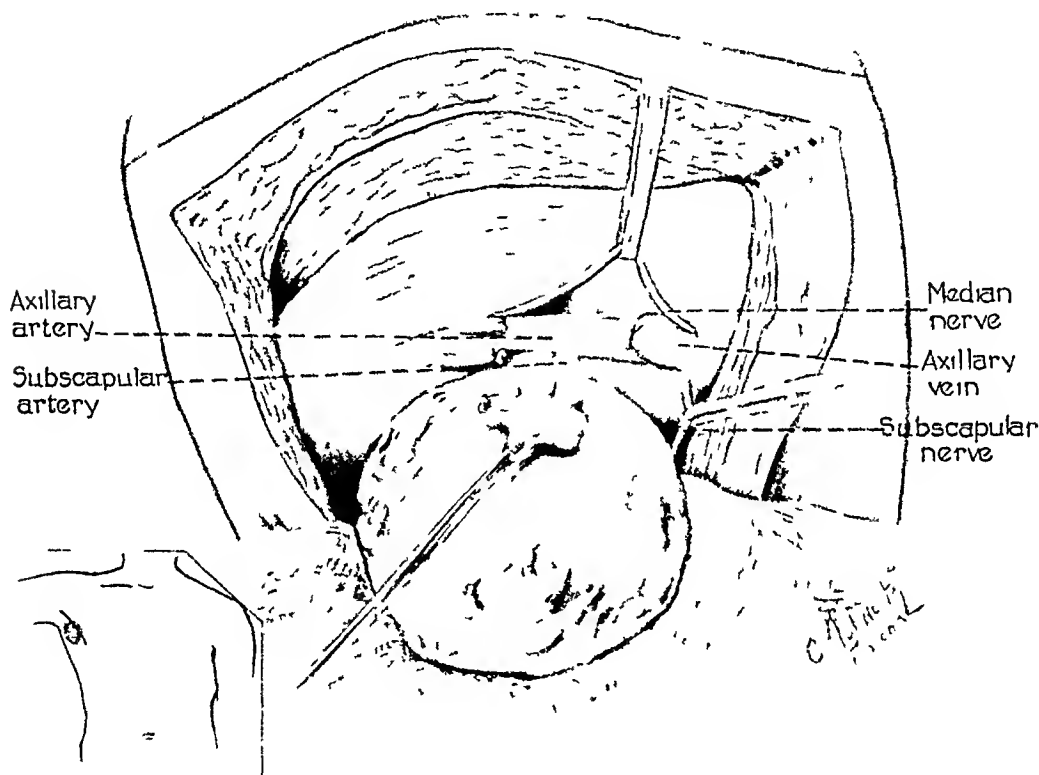


FIG 1—Findings at operation. The subscapular artery communicated with the sac through two openings.

Operation—September 5, 1946. Under nitrous oxide oxygen ether anesthesia, an incision was made from the outer third of the clavicle across the anterior axillary fold onto the upper third of the arm. The pectoralis major and minor were cut near their insertions, exposing a large, pulsating mass, closely associated with the axillary artery and vein and occupying the entire subscapular region of the axilla. The origin of the mass could not be determined accurately at this point, but it appeared to arise from the axillary artery. Controlling tapes were placed around the axillary artery and vein, proximal and distal to the mass, but were not tied. Dissection of the aneurysm was commenced at its lowest extent on the subscapularis muscle and continued upward to the axillary vessels. The subscapular nerve, densely adherent to the sac, was isolated and protected. At the apex of the mass, the axillary vein was so incorporated into the wall of the sac that it could not safely be dissected free. Therefore, after ligation, a portion of the axillary vein was retracted with the sac. The origin of the aneurysm was now apparent (Fig 1). It arose from the subscapular artery 1.5 cm from the axillary artery.

After complete dissection, the aneurysm now hung from the subscapular artery similar to a pear on a bough. The axillary artery represented the branch, the subscapular artery the stem, and the aneurysmal sac the fruit. It was possible to ligate and divide the subscapular artery between the sac and the axillary artery, making removal of the aneurysm possible without interrupting the continuity of the axillary artery.

The specimen consisted of an aneurysmal sac, measuring 8.5 x 6 x 5 cm to which a segment of the axillary vein was attached. The subscapular artery was adherent to the apex of the sac and continued along its posterior wall. It communicated with the sac through two openings 1 mm in diameter. There was no communication between the sac and the axillary vein. The inner lining of the aneurysm was smooth and its lumen was partially filled with laminated blood clot.

Postoperative Course—The postoperative course was smooth and the patient was discharged on the 14th postoperative day.

Follow Up—February 8, 1947. The axillary incision was firmly healed and there was complete range of motion of the right shoulder. There was no swelling of the right arm or forearm and the brachial and radial pulses were present. There was no recurrence of the aneurysm. The patient had returned to work as a logger.

DISCUSSION

Recently emphasis has been placed on the importance of maintaining the continuity of the main arterial channel, whether by endoaneurysmorrhaphy, lateral suture, end to end anastomosis or vein graft, in the surgical treatment of traumatic vascular lesions. Even should the collateral circulation be adequate for the viability of the peripheral tissues, complete division of the major vessel often results in lowered work capacity and intermittent claudication. It is not difficult to maintain the integrity of the major vessel when a vascular lesion arises from one of its branches. Ligation of the branch with excision of the aneurysm can be accomplished without disturbing the main vascular channel. However, to make this possible, established technical procedures of vascular surgery must be observed: absolute hemostasis, wide exposure, proximal and distal control of the main vessel, and meticulous dissection are imperative.

SUMMARY

1. A case of traumatic aneurysm of the subscapular artery is reported.
2. Ligation of the subscapular artery and excision of the aneurysm, without interrupting the continuity of the axillary artery, were possible.

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CYST OF THE SPLEEN

Case Report

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PRIMARY CYSTIS OF THE SPLEEN, as distinguished from those occurring as a result of degenerative processes due to disease or trauma, are apparently rare. In the case herein reported, the presenting symptoms and signs were of thoracic origin. As far as we have been able to determine, this is the only case in which the spleen containing a cyst has been successfully removed through a transthoracic approach.

Mrs. M. M., 39 years of age, at the time of our initial observation on April 13, 1946, was six weeks pregnant, this being her first pregnancy. She was seen first because of pain in her chest. Physical examination of the chest, at this time, was negative. Five days later, a roentgenogram of her chest, taken because of pain and bronchial breathing in the left chest, showed considerable density at the left base. Evidence of effusion subsequently appeared and a thoracentesis yielded clear fluid which was negative on culture and guinea pig inoculation for mycobacterium tuberculosis.

She was admitted to Columbia Hospital on April 29, 1946. A roentgenogram of her chest, taken the morning after admission, showed the same appearance at the left base as previously. Some hours later, she complained of sudden, sharp pain in the left chest with respiratory distress. A marked increase in the effusion was noted on roentgenologic examination. Thoracentesis now yielded rather heavy, turbid fluid which was sterile on culture. The fluid contained many cholesterol crystals but no cells. This latter finding suggested that the fluid might be of a cystic origin (Fig. 1). For the next few days, there was no increase in the pleural effusion, but there was an increase in her fever and vaginal bleeding appeared. Since it was evident that the patient was aborting, a curettage was accordingly performed on May 3, 1946, five days after admission to the hospital.

As her symptoms improved, more adequate roentgenologic examination was possible. In addition to the effusion in the posterolateral aspect of the left chest, a spherical, calcified lesion was seen in the region of the left side of the diaphragm, the exact position of which in relation to the diaphragm could not be accurately determined, at this time (Figs. 2 and 3). Subsequently, the stomach was outlined with barium and a gas producing substance was given by mouth to determine the relation of the stomach to the calcified lesion. A diagnostic pneumoperitoneum was also induced. The preoperative roentgenologic diagnosis was a cystic mass with a calcified wall in the abdomen on the left side just below the diaphragm. The contents of the cyst were believed to have erupted through the diaphragm and to have secondarily involved the pleural cavity.

On May 20, 1946, three weeks after admission to the hospital, a thoracotomy was performed under pentothal anesthesia, through a posterolateral incision. The 9th rib was resected from the transverse process to the anterior axillary line. When the pleura was opened, a large amount of turbid fluid containing fibrin was encountered. The visceral pleura was moderately thickened. The diaphragm was incised and a large cyst encountered which contained thick, yellowish, granular material. Since it was believed that the cyst arose from the spleen, splenectomy was performed. Air tight, intercostal drainage was instituted after closure of the diaphragm and chest wall.

CYST OF SPLEEN

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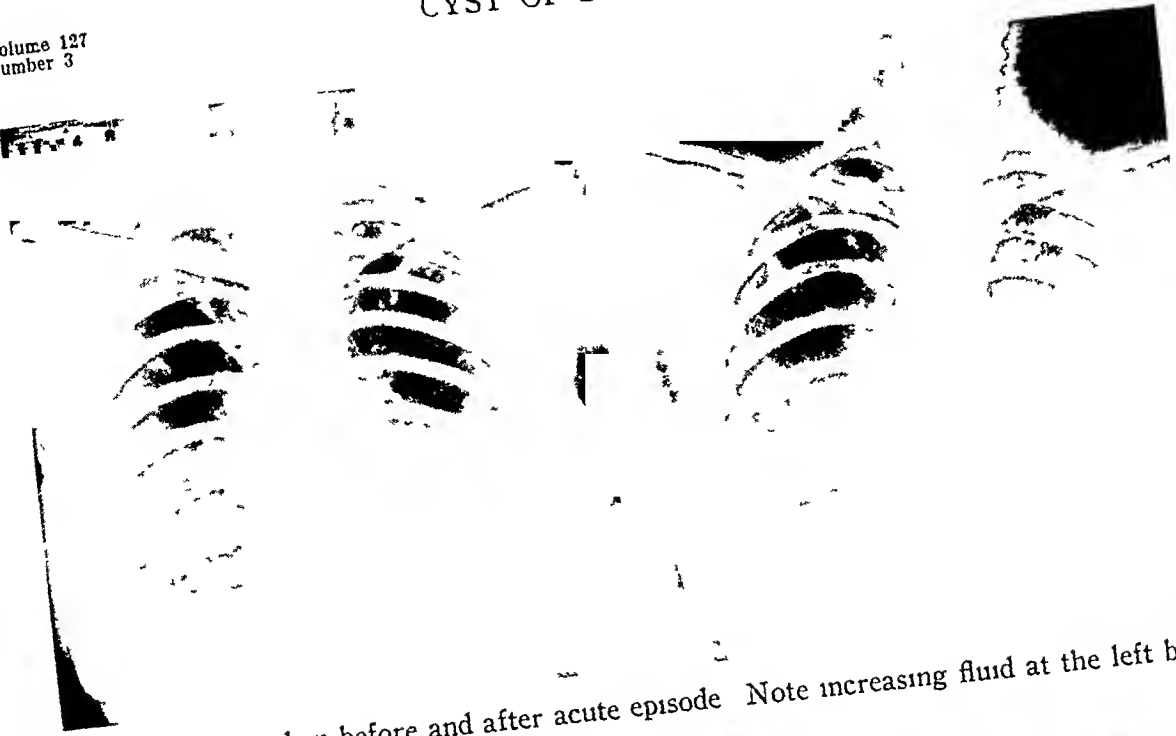


FIG 1—Plates taken before and after acute episode Note increasing fluid at the left base



FIG 2—Bucky diaphragm plate showing calcified cyst, position indeterminate

The patient's immediate postoperative course was uneventful except for a high fluctuating fever which continued for five days. She was discharged from the hospital 18 days following the operation, in good condition.

Pathologic examination by G H Hansmann, M D, revealed that the gross specimen (Fig 4) consisted of a spleen which weighed 305 Gm and measured 15 cm in length, 10 cm in width, and 3 cm in thickness. The lower



FIG 3—Gas in the stomach shows that the cyst is extra gastric which is above and behind the stomach

half of the spleen was of normal size, shape, color and consistency, but the upper half contained a doughy cyst which measured 9 x 8 x 7 cm. The cyst wall, which was pale in color and had a leathery consistency, appeared to be enclosed within the splenic capsule, but was separated by a portion of the capsule from the splenic pulp. Blood vessels could be demonstrated passing from the spleen to the surface of the cyst. When opened, the cyst was found to be filled with pultaceous material of putty-like consistency. Careful search was made, but no hair, teeth, bone, echinococcus ova or hooklets were

found. Wet smear of the cyst contents revealed the presence of large numbers of cholesterol crystals and flakes of dead epithelium. Upon evacuation of the contents of the cyst, the inner wall was found to be atheromatous and had a distinct mammilated appearance.

Subsequent histologic examination of the walls of the cyst revealed thick, hyalinized, fibrous tissue containing areas of bone with well-defined marrow cavities, areas of calcification, and others of necrotic, flaky, material in which there were many cholesterol clefts. The closest approach to an epithelial

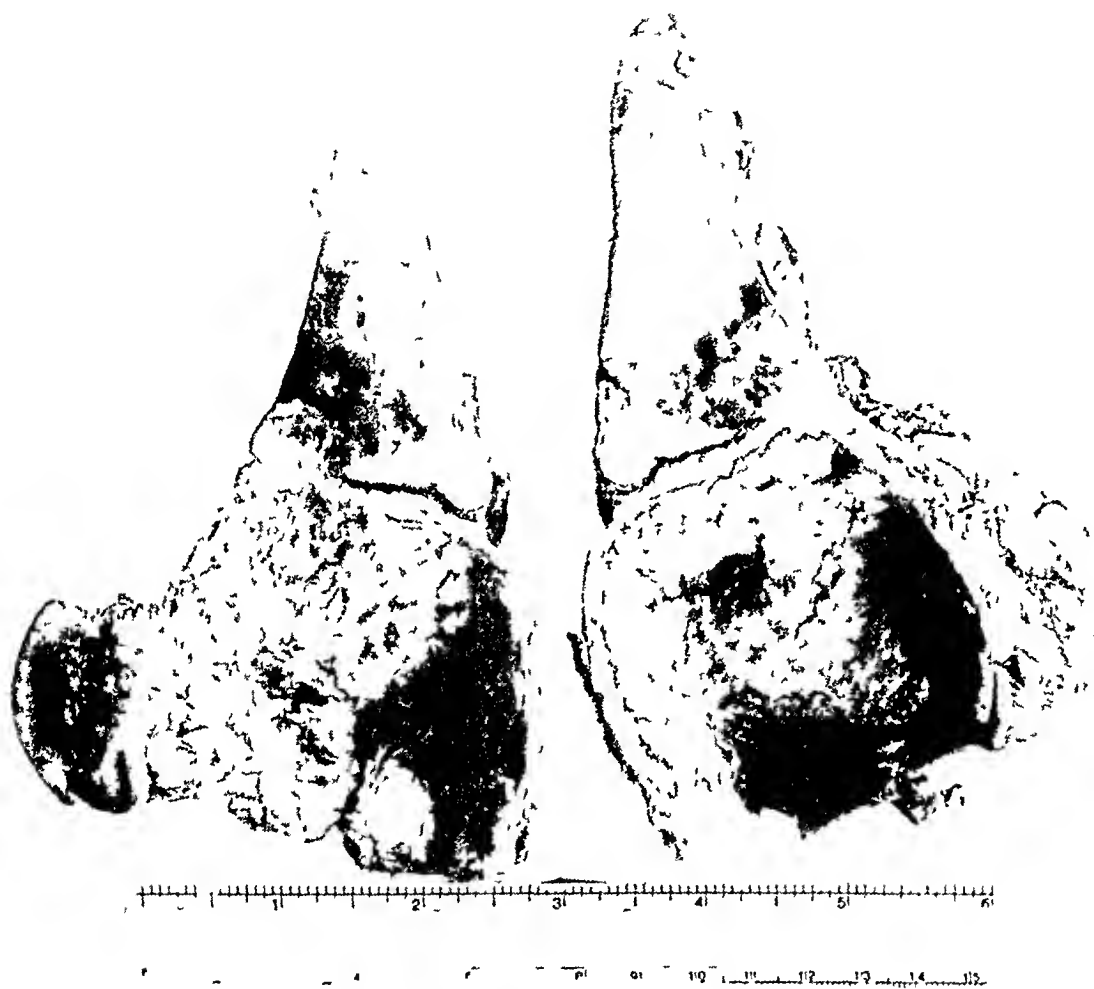


FIG 4—Removed spleen with cyst

lining consisted of calcified areas with the configuration of nuclei about which were many cholesterol clefts. Tissue from the boundary between the cyst and splenic pulp revealed thickening of the splenic capsule with some compression of the underlying pulp. Tissue from various areas of the spleen revealed normal splenic structure. The pathologic diagnosis was an epidermoid inclusion in the spleen with cyst formation.

COMMENT

Unlike cysts of the ovary, liver, kidney or other abdominal organs, cysts of the spleen are relatively rare. The first record of any splenic cyst was that

of Andral¹ who discovered the condition in an autopsy in 1829 Pean,² in 1867, was the first to remove successfully a splenic cyst Ecchinococcus cysts of the spleen occur about twice as frequently as various forms of nonparasitic cysts, and false cysts about four times as often as true cysts Epidermoid cysts, according to Shawan,³ usually occur in young people of either sex These cysts, according to Montgomery, *et al*,⁴ are usually large, solitary, and lined with stratified pavement epithelium with prominent intercellular bridges Custer, as quoted by Montgomery, states that some cysts of this type have been described in which the cavity was filled with sebaceous material and hair and have been reported to weigh as much as 3 Kg, to have contained up to 1,500 cc of watery, chocolate colored material, and to have contained cholesterol crystals Fowler⁵ pointed out that enucleation of the cyst is rarely feasible and advocates splenectomy as the treatment of choice

It is interesting to conjecture that our patient's first pregnancy incited her cyst to activity Fowler reported some association between pregnancy and the incidence of splenic cysts, (quoted by Naidu⁶)

The unusual feature of our case was that the original symptoms were of thoracic origin, the contents having spilled into the pleural cavity

SUMMARY

A case of an epidermoid cyst of the spleen with symptoms of thoracic origin is reported Splenectomy was performed through a transthoracic approach We have found no similar case reported in the literature

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MARROW-NAILING OF RECENT FRACTURES, PSEUDARTHROSIS AND BONE PLASTIC

EXPERIENCES IN 100 CASES

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THE MARROW-NAILING by treatment of fractures of the long bones has as its originator Kuntscher, of Kiel, Germany. In 1940, he published¹ his first results with the new method. I have used marrow-nailing in certain cases since 1943, and have, in *Acta Chirurgica Scandinavica*, vol 90, 89-104, 1944, described our first 28 cases. Since that time we have undertaken marrow-nailing in 72 additional cases—and we are now rather experienced in this field. Our results are still encouraging. On account of the war and the interrupted communications between the various countries, the method of medullary-nailing has not become as well known as it deserves. To judge from the scientific American literature which has come to Sweden during the past few years, the method does not seem to have been used in America, and I have, therefore, thought that a report of our experiences might be of interest to American surgeons.

The aim of medullary-nailing is to keep the bone fragments in position by means of a long nail inserted into the marrow cavity. As the nail is driven in from a hole chiseled in the corticalis far from the site of the fracture, the latter is not exposed and it is not a question of open reduction. The nail is U- or rather V-shaped and does not fill the whole marrow cavity and, thereby, causes very little damage to the bone marrow and the endosteum but gives, nevertheless, a firm fixation. The nail reaches, as indicated in Figure 1, the endosteum only in three narrow places, and as it is comparatively thin (1.5-2 mm) it only causes a moderate compression of the marrow. Through its angulation and the hardness of the steel, the nail, in spite of its thinness, is very resistant to flexion and if it fits well into the marrow cavity it gives a very firm fixation.

In fractures of the femur the nail is inserted from the upper surface of the trochanter major, either percutaneously or through a small incision. No chiseling is needed as the bone here is very soft. When inserting the nail into the other long bones, such as the humerus, radius, ulna or tibia, a small hole must be chiseled or bored through the corticalis at a suitable distance from the site of the fracture.

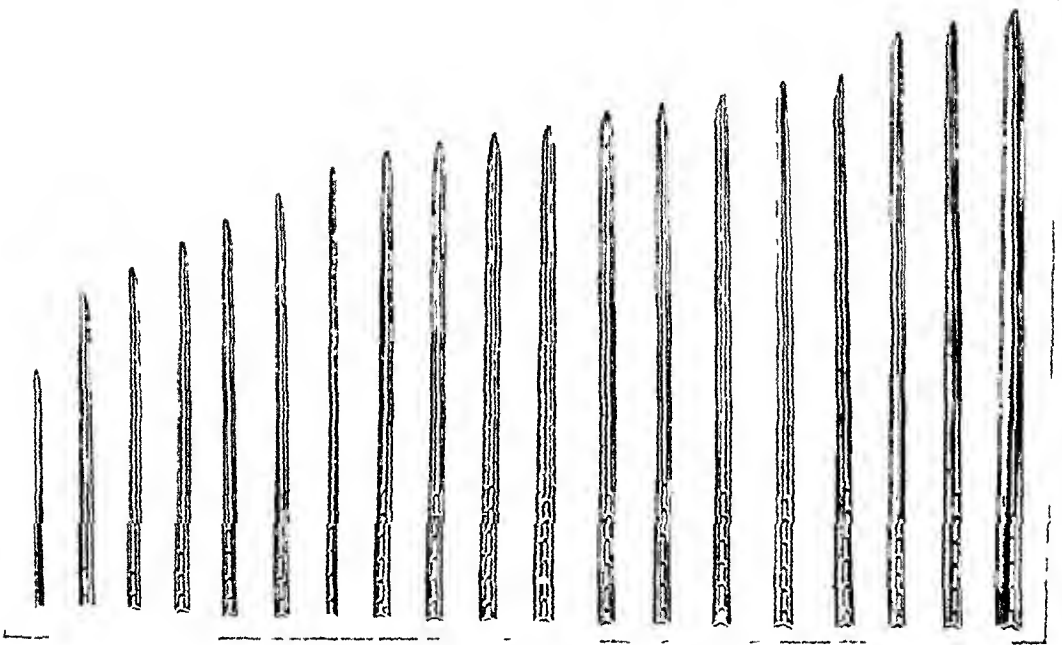
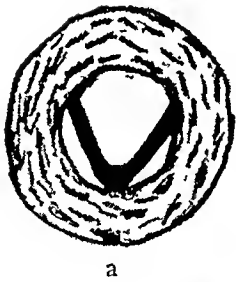


FIG 1—(a) Medullary Nails (b) (Below) showing detail of design and cross-section of nail *in situ*



a

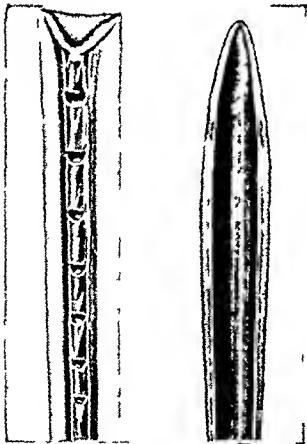


FIG 1b

The difficulty is to get such a good closed reposition that the nail can be inserted from one fragment directly into the marrow cavity of the other. Several apparatuses for facilitating this reposition have been constructed. Kuntschei attaches great importance to the closed reposition, as the exposure of the fracture site and the open reposition involves risk of infection and other complications. Nowadays, with penicillin, this risk is, however, very slight. As my cases show, it is sometimes necessary to use open reposition. If the closed reposition is successful the marrow-nailing is only a small operation, which causes the patient only little strain and little risk. Here, we have one of the great advantages of the new method over the ordinary osteosynthesis.

The nail must be inserted under fluoroscopic supervision, or repeatedly checked by several roentgenograms. We have used the latter method and found it satisfactory. One may also, in order not to risk having to take out the nail and change its position, first insert a "leader" (Kirschner needle),

which is done in operations on fractures of the femoral neck.

We used nails manufactured by Ericsson's Instrument Company, in

Gothenburg, Sweden* These are made of rustless steel Our first nails, however, were not sufficiently strong and were bent at the site of insertion or later through the strain of the fracture The new ones are more satisfactory The nail must not, however, be manufactured of too hard steel, which would prevent the flexion necessary to insert the nail into the marrow cavity from the small hole in the corticalis The instruments needed are very simple (Fig 2) Of course, it is necessary to have a good apparatus to withdraw the nail if it happens to lie in a wrong position and after healing of the fracture It is, naturally, necessary to have several nails of different lengths and widths at hand (from 10 to 45 cm [Fig 1])

Up until January 5, 1946, we have used marrow-nailing in 100 cases of which 69 have been recent fractures, 24 pseudarthrosis and 7 cases of bone plastics The cases are divided as seen in Table I

TABLE I

	Recent Fractures	Pseud- arthrosis	Bone Plastic	Totals
Femur	13	6	3	22
Tibia	28	3	1	32
Humerus	15	13	3	31
Radius or ulna	12	1		13
Metacarpal	1	1		2
	69	24	7	100

As it would require too much time to describe all our nailed cases, a brief account, only, will be given of some characteristic cases in each group

A RECENT FRACTURES

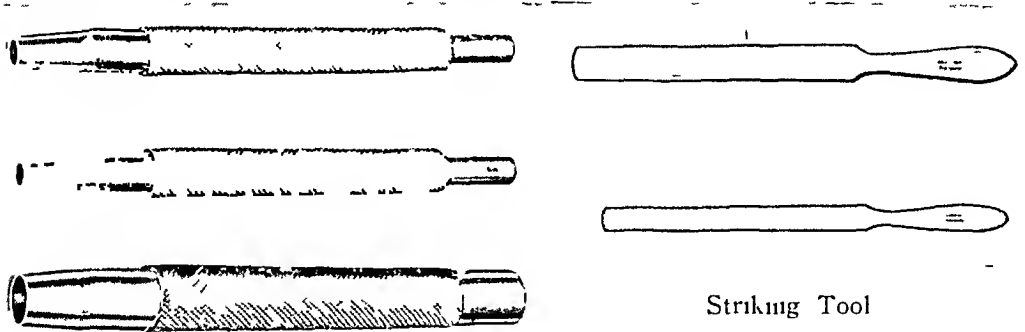
Case 1—Man, age 31, with an oblique fracture of the femur When extension treatment did not result in good position and roentgenograms showed muscle interposition, medullary-nailing was done on April 30, 1943 The interposition made open reduction necessary The nail was inserted from the upper surface of the trochanter major A good position, with firm fixation and complete freedom from pain was immediately obtained The patient could sit up after a week, and three weeks later he was able to bear weight on his leg When he was discharged, seven weeks after the operation, he walked easily with a cane There is an early and powerful callus formation The nail was later removed

Case 2—A woman, age 45, sustained a complicated transverse fracture of the right femur on November 14, 1943 Immediately upon admission operation was performed, with careful removal of all the injured tissues and open reposition of the fragments A marrow nail was inserted from the trochanter major Primary suturing and healing As the fixation was not absolutely stable, another nail was inserted a week later, with better results The patient got up soon, and was able to bear weight on her leg four weeks after the second operation (Fig 3) The nail was removed after six months

* Zimmer Manufacturing Co, Warsaw, Indiana

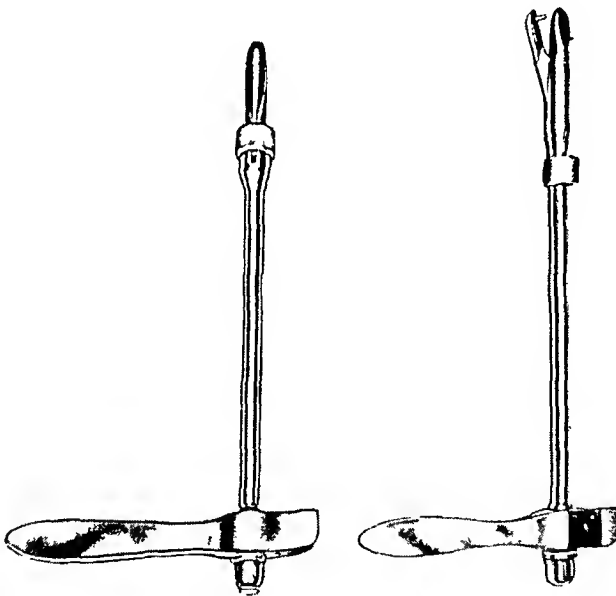
Case 3—Man, age 33 Splinter fracture of the humerus, with bone interposition. Extension treatment did not result in good position. Open reduction and marrow-nailing. Firm fixation was obtained. No plaster splint was applied. Six weeks after marrow-nailing shows roentgenographic consolidation of the fracture (Fig 4).

Case 4—Man, age 60 Fracture of the lower leg. Extension treatment did not result in good position. Instead of osteosynthesis we chose medullary-nailing. The nail



Driver

Striking Tool



Nail-drawing instrument

FIG 2—Instruments used in marrow-nailing

was inserted through a small hole chiseled out in the upper part of the tibia on February 8, 1945. Good position was obtained, but when the distal stump was too short to give as firm fixation as was desired a plaster encasement was applied for some weeks. The leg could bear weight six weeks after nailing (Fig 5).

Case 5—Man, age 20 Transverse fracture of the radius and ulna. After repeated reductions a good position of the ulna was obtained, but not of the radius fragments.

Medullary-nailing was, therefore, chosen instead of osteosynthesis, the nail being inserted through a small hole in the distal end of the radius. A plaster splint was applied for four weeks. The man had recovered his working capacity six weeks after operation.

It is extremely important to the healing of the fracture that absolutely firm fixation is obtained in medullary-nailing. For this, one must choose a nail which fits well into the marrow cavity and ascertain that the latter is of fairly even width. This is the case in the cavity of the femur and to a certain degree in the radius and ulna, but the tibia and humerus often have rather symmetrical marrow cavities. Thus, the best results are obtained in nailing of femoral fractures. The nail must be wide enough so that it establishes firm contact with the wall of the marrow cavity, mainly, in order to prevent rotation between the fragments. One can estimate from the size of the marrow cavity in the roentgenogram about what size nail to choose. According to Fischer, with a focal distance of 75 cm the marrow cavity is



FIG 3—Case 2 (a) Open fracture of the femur (b) After marrow-nailing

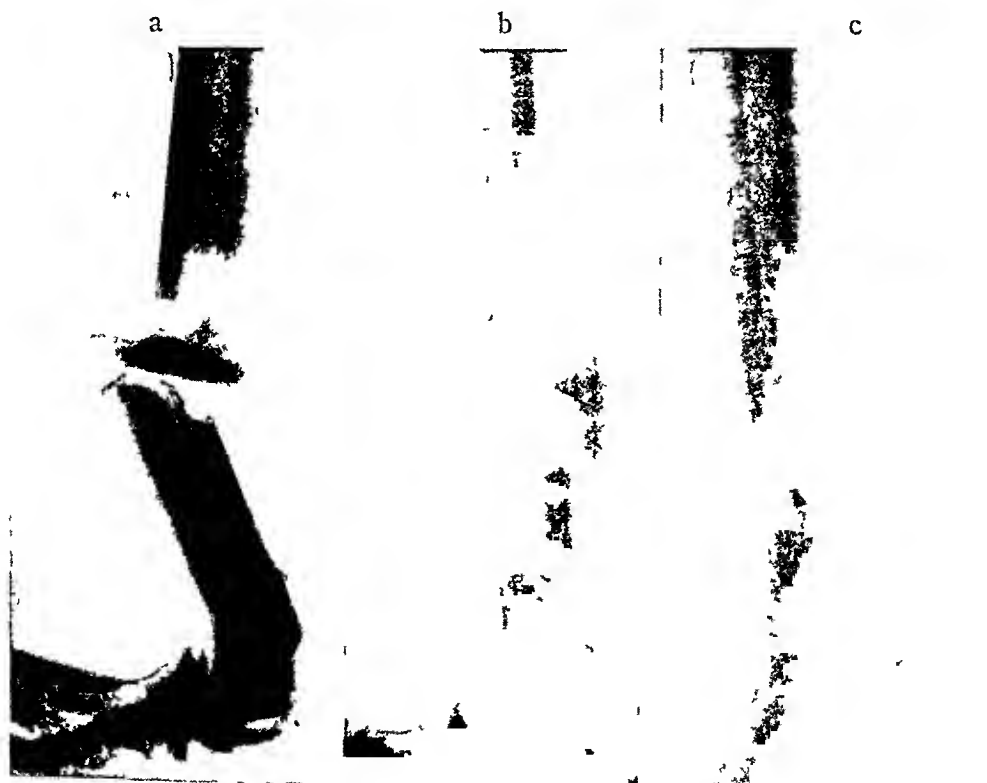


FIG 4—Case 3 (a) Fracture of the humerus, with bone interposition (b) Three weeks after operation (c) Bone consolidation six weeks after marrow-nailing

really 1 mm smaller than it appears on the roentgenogram. The conditions are not so favorable in the tibia as they are in the femur, for, here, the cavity is narrowest in the middle. Consequently, it is easy to obtain firm fixation of fractures situated in about the middle of the tibia but not of ones situated more distally or proximally.

If full stability is not obtained with one nail, it is wise to insert another one (Case 2). This needs to be done more often in the cases of bones with uneven medullary cavities (tibia and humerus) than of ones with an even canal.



FIG 5—Fracture of the lower leg before and after marrow-nailing

Medullary-nailing has given the best results in fractures of the femur. The advantages of this method are also greatest in these cases. Previously, the patients had to lie in bed for two or three months and undergo extension treatment for long intervals, a procedure which is irksome to the patient and requires much attention from the hospital staff. The long stay in bed also involves the risk of complications in the air passages, at least with older persons. Now these patients can be allowed up early, and can soon begin to bear weight on their leg, thus avoiding stiffness in the joints and muscular atrophy. Another great advantage is that the patients are immediately rid of pain. It is also maintained by Kuntschei, and others, that the nailing accelerates the formation of callus, thus, considerably reducing the time before the patient is able to resume his normal occupation.

Fischer also recommends medullary-nailing for supracondylar femoral fractures. The greatest advantage in these cases is that the nail keeps the fragments in position, which is difficult to obtain with extension treatment. When the nail can only be inserted 3-4 cm in the distal fragment it is necessary to apply a plaster encasement for some weeks, and early weight-bearing is out of the question.

The *advantages of medullary-nailing*, particularly in femoral fractures, are, in my experience, and that of others

- 1 Shortened stay in bed
- 2 Simplified after-treatment—no extension
- 3 Reduced pains and other subjective troubles
- 4 Less risk of stiff joints, muscular atrophy and circulatory disorder
- 5 Shorter hospitalization and probably earlier acquirement of working capacity

No definite agreement has been reached about the *indications for medullary-nailing*. Some surgeons have narrow indications, and others very wide ones. Kuntscher says that the method is suitable for all transverse, oblique and spiral fractures of the long bones, and Pascher² goes so far that he considers it absolutely indicated in all transverse, all oblique fractures with a poor healing tendency or where there is risk of slipping, and in all fractures in old persons, where long stay in bed should be avoided. Bohler, who is a strong opponent of open treatment for fractures, recommends the method warmly for gunshot fractures, thus, open fractures, and seems to be a strong advocate of medullary-nailing, on the whole. Others, for example K. H. Bauer,³ reserve the method for more special cases, *e. g.*, for times when it is necessary for some reason to make an open reduction.

The marrow-nailing involves, of course, certain risks. Above everything, we must think of the danger of bone *marrow destruction*, *fat embolism* and *osteomyelitis*. Experience has already shown that the damage which the nail causes to the bone marrow is of no or little practical significance. It is recommended, however, that the nail be removed when full consolidation is established. We have done that in the majority of our cases. The removing of the nail is a simple operation. After a few months the nail generally lies fairly loose in the marrow cavity. On the other hand, there is a certain risk of fat embolism. At least two deaths from fat embolism after medullary-nailing are reported (Kuntscher and Habler). Detailed information is lacking, and it is impossible to decide whether the fat embolism occurred as a result of the fracture or of the nailing. Osteitis has developed in a few cases (Kuntscher, Fisher, and others). In most of them it was a question of complicated fractures. Extended osteomyelitis, generally, does not develop, but only restricted osteitis, with local sequestration, mainly due to the fact that the pus in the marrow cavity is led off along the nail. Thus, according to Kuntscher, Bohler, and others, there is never any enclosure of pus in the cavity with rising pressure, which is generally considered to be the cause of extending osteomyelitis. Kuntscher says that whenever there is infection,

one should drain, so that the pus is easily able to drain off, but not remove the nail since it generally heals in spite of the infection. That is also my experience. If the nail is removed, the infection grows worse because the fragments no longer lie still.

B PSEUDARTHROSIS

The treatment of pseudarthrosis has always caused surgeons great difficulty. Well-nigh countless methods have been tried but none has so far proved itself to be supreme. The problem has now been actualized through the increase of the number of cases due to the gunshot injuries sustained during the war. Even here, medullary-nailing has been used and I have, up to date, nailed 24 cases of pseudarthrosis. The results are thus far satisfactory. In the cases which I have been able to follow for a sufficiently long time, the bone-healing was satisfactory except in three cases where inflammation recurred after operation.

My experience is that the marrow-nailing will simplify the pseudarthrosis problem considerably. The literature is still very scanty. K. H. Bauer, who otherwise is reserved concerning this method, recommends it in cases of pseudarthrosis, and so do Bohler⁴ and Cellarius,⁵ from Kirschner's Clinic, who report the results of 18 cases which were earlier treated in vain by other methods. In at least 15 of these cases bone-healing took place within 6-8 months after marrow-nailing.

In order to hasten the bone-healing, the marrow-nailing may be combined with other operations, such as bone transplantation, either in the form of bone clips, according to Levander, or by covering the pseudarthrosis with a larger bone piece. Often, marrow-nailing alone is sufficient. All my cases, with the exception of four, were Finnish soldiers injured in the war. Appended are reports of some characteristic cases.

A PSEUDARTHROSIS OF THE FEMUR

Case 6—A 22-year-old sergeant sustained a gunshot fracture of the femur a few fingersbreadth below the trochanter minor, on October 22, 1941. He was treated in Finland with extension, plaster encasement, *etc.* He arrived at Sahlgrenska Hospital, July 22, 1942, with his leg in a plaster encasement. When the plaster encasement was removed, the bone ends slipped apart. The wound was revised, sequestrectomy performed, and wire extension instituted. No healing took place, osteosynthesis with transplantation of bone clips, according to Levander, was done in December. Consolidation did not result, and, in March, 1943, medullary-nailing was done after revision with freshening of the bony ends. Firm fixation was obtained at the site of the fracture, and three weeks later the patient was able to walk about outdoors, with two canes, and well able to bear weight on the leg. When he returned to Finland in October, six months after the operation, the fracture was consolidated and he walked well.

Case 7—A 34-year-old soldier sustained a complicated femoral fracture through a shell injury in December, 1941. On admission to the Sahlgrenska Hospital, February, 1943, the wound was healed but the bone was not stable. Medullary-nailing was performed, March 27, 1943, after freshening of the bony ends and excision of all fibrous tissue. Firm fixation was obtained and full stability at the site of fracture. Two weeks later the patient was able to stand on his leg. After another two weeks he walked with



FIG 6—Case 7 (a) Pseudarthrosis femoris (b) After reposition (c) After marrow-nailing (d) Three months later

two canes. When he was discharged three months after operation, the bone was stable, he could walk well and there was increased callus formation. Report from Finland says that full consolidation has occurred (Fig 6).

Case 8—In March, 1940, a 27-year-old soldier was hit by a shell splinter which caused a complicated femoral fracture. He was treated with extension and a plaster encasement. On admission to the Sahlgrenska Hospital in February, 1943, three years after the fracture, pseudarthrosis had developed. The leg was considerably shortened, the knee ankylosed, and there was paralysis of the peroneus muscle, with severe muscular atrophy. The patient was not able to stand on his leg at all. In February, osteosynthesis with bone transplantation was done. There being no signs of healing, the pseudarthrosis was revised again two months later, with excision of all the fibrous tissue and freshening of the bony ends, and medullary-nailing was done. Firm fixation and freedom from pain were obtained immediately, and the patient, who had lain in bed for nearly three years, was able to begin to bear weight on his leg after about a week. When he returned to Finland, three and one-half months after the operation he stood well on his leg, and walked with two canes. The bone was absolutely stable, but there was only a slight increase in the callus formation (Fig 7).



FIG 7—Case 8 (a) Pseudarthrosis of the femur (b) After marrow-nailing (c) Four months later

In six cases of pseudarthrosis of the thigh bone which persisted from one and one-half to three years, and in spite of attempts with many different meth-

ods, it was not possible to attain osseous healing. In several of the cases all our old possibilities were exhausted and it is probable that the patients would have been left with the pseudarthrosis for the rest of their lives if we had not resorted to medullary-nailing. Also, it was a great mental relief to these invalids to be rid of pain and be able to get up soon after the nailing. Two of them had almost continuously been confined to bed for two or three years. In all cases the nail was inserted from the upper surface of the trochanter, and before insertion the wound was revised, with excision of fibrous tissue and freshening of the bony ends. As in these cases the fracture was exposed it was not difficult to get the fragments into such a position that the nail came into the marrow cavity of the distal fragment. In two of the cases, persisting fistulae, with a slight discharge, were present at the time of the operation. In one case the fistula healed soon after the operation, in the other there was still slight suppuration at the time the patient was discharged. In order to avoid the risk of reactivation of a latent infection sulfathiazole was in all cases introduced into the operation wound. The postoperative treatment was the simplest imaginable. After one or two weeks in bed the patient was allowed to get up. The prolonged stay in bed before the operation had produced more or less marked stiffness in the joints as well as muscular atrophy, necessitating intensive physical therapy.

Regarding the permanent results, in at least three cases out of six, consolidation had developed before the patient was discharged. The three others returned home so early that the final results could not be judged. There is much to indicate, however, that osseous healing will take place in these cases, as well, within reasonable time. Even if the results may not be 100 per cent perfect, experience, up to the present, indicates that the new method is vastly superior to the old ones for treatment of femoral pseudarthrosis.

Wherein do the advantages of marrow-nailing lie, and why is it that it has such a favorable effect in cases of pseudarthrosis? The most important condition for osseous healing is, of course, absolutely firm fixation of the fragments, and particularly firm fixation is just what is obtained with medullary-nailing, especially in cases of pseudarthrosis with sclerosed bone. Another important factor is early weight-bearing and after marrow-nailing the patient can begin weight-bearing on his leg almost immediately.

B OTHER TYPES OF PSEUDARTHROSIS

Case 9—A 25-year-old Finnish soldier was injured in the arm by a shell splinter in August, 1941. A defective humerus pseudarthrosis followed. After repeated revision, osteosynthesis was performed, September 7, 1942, but no consolidation resulted. Medullary-nailing was, therefore, done on June 11, 1943. The nail could not be placed centrally into the peripheral stump, and, consequently, the site of the fracture afterwards was not stable. Another nail was driven in on October 26, after extraction of the former one, nor was this nail inserted in the ideal position. To increase the stability a piece was taken from one of the tibiae and placed over the fracture. The wound healing was primary, and good stability resulted. Osseous healing has later occurred.

Case 10—A 21-year-old Finnish soldier sustained a complicated fracture of the right upper and forearm in February, 1943. In both places pseudarthrosis developed. He arrived at the Sahlgrenska Hospital in June, and on June 22 medullary-nailing was performed to the humerus pseudarthrosis after excision of the fibrous tissue. The nail could not be placed in the desired central position, and full stability was not obtained. The arm was, therefore, placed in a plaster encasement. On November 12, a medullary-nail was inserted in the radius as no stability had been obtained in spite of prolonged conservative treatment. This bone was fractured in two places and the nail was driven in from the distal end of the radius through the intermediate fragment, a long way into the proximal one. Excellent stability resulted (Fig 8). However, slight suppuration occurred afterwards. When the patient returned to Finland in January, 1944, the fracture in the humerus felt consolidated, roentgenograms showed only moderate callus formation, and the suppuration in the forearm had almost entirely dried up.

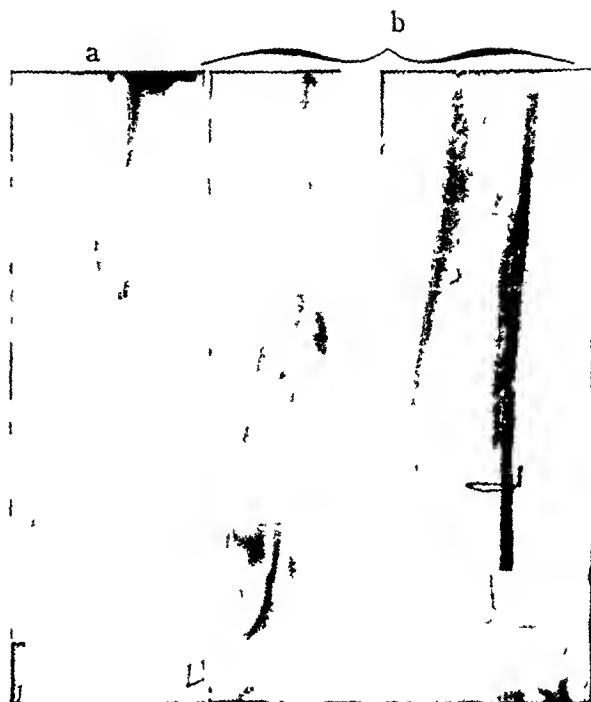


FIG 8—Case 10 (a) Pseudarthrosis of the radius in two places (b) After nailing



FIG 9—Case 11 (a) Three-year-old pseudarthrosis of the humerus (b) Four months after marrow-nailing

Case 11—A woman, age 70, sustained a fracture of the right humeral diaphysis on October 17, 1941. Osteosynthesis with cerclage was performed. The threads cut in and typical pseudarthrosis developed. On July 27, 1942, the bony ends were revised and a large amount of bony shavings were transplanted, in accordance with the method of Levander. No healing resulted and a new operation was performed on January 8, 1943, with transplantation of a bony plate from the tibia over the place of pseudarthrosis. The fracture still did not heal. On May 15, two fairly narrow nails were inserted. Roentgenograms in October showed that the nails had broken in the middle of the pseudarthrosis. On October 22, the broken nails were extracted and two coarser ones were inserted after revision of the pseudarthrosis with removal of the fibrous connective tissue. Full stability was then obtained and, on February 1, 1944, roentgenograms showed that osseous healing had occurred three months after the last medullary-nailing. The nail was later removed (Fig 9).

This case is of the greatest interest. The 70-year-old woman with a three-year-old pseudarthrosis of humerus shows osseous healing three months after marrow-nailing. Before we had tried all our old methods to obtain bone healing, such as osteosynthesis, bone transplantation, *etc*, to no purpose.

Case 12—A man, age 35, sustained a complicated fracture in his lower leg in February, 1942, resulting in prolonged suppuration and pseudarthrosis. In October, 1943, medullary-nailing was performed after chiseling off the end of the fibula, excision of the

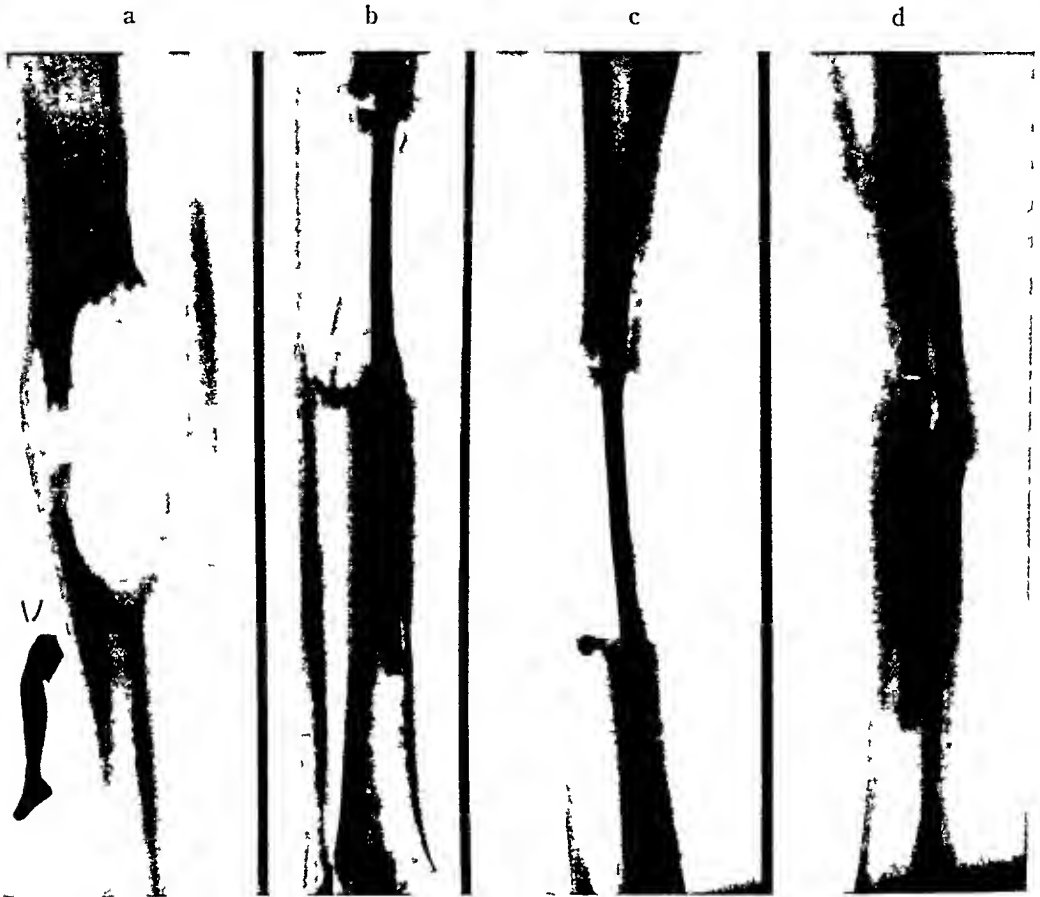


FIG 10—Case 13 (a) Cystic giant cell sarcoma of the tibia (b) After resection, bone transplantation and marrow-nailing (c) Four months after operation (d) Twenty months after operation

fibrous tissue in the pseudarthrosis and chiseling-off of the tibial ends. Plaster was applied. The wound healing was primary, and good stability was obtained. Six weeks later the leg could be weight-bearing. Full consolidation after four months.

It is more difficult, in cases of pseudarthrosis, to do the nailing, than in cases of recent fractures. The sclerosis in the end of the bone offers powerful resistance and may even make it impossible to insert the nail. Thus, in one case, not reported herein, it was not possible to drive the nail through the strongly sclerotic bone (tibia), and medullary-nailing could not be carried out. The inserted nail sat so firmly fixed in the bone that it could not be drawn out, and a piece of it had to be left there.

C BONE PLASTIC

In the cases where there is a question of shortening or lengthening a leg, or to cover a deficiency of a bone marrow-nailing is very useful, especially as the nail gives stability to bone and transplantation. The following cases illustrate this. The cases speak for themselves, and further comments are unnecessary.

Case 13—Man, age 27, has been suffering from pains in left lower leg. Through misplacing his step November 27, 1943, a severe pain in the leg developed. Roentgenograms showed fracture through a cystic tumor in the middle of the lower leg. Test extirpation from the cystic tumor showed osteitis fibrosa, with giant cell sarcoma, April 1, 1944. Resection of about 10 cm of the tibia. Fixation of the bone ends by means of a large-sized medullary-nail. Intraplantation of two 9-10 cm bone pieces taken from the right tibia. Plaster encasement.

January 25, 1946. The patient had not been examined since October, 1944, due to illness of nerves. Examination shows that both legs are equally long. No instability at the site of operation. Normal movability in knee and foot joint. Good weight-bearing capacity. Roentgenograms show good healing of the bone transplantation, in spite of the fact that the nail had broken. A small, narrow crack in the bone transplantation. Injury from tramcar accident on January 14, 1946 (Fig. 10).

Case 14—Female, age 12. The right leg, as a result of a congenital disturbance in the growth, is 20 cm shorter than the left one. The difference seems to be constant. On August 23, 1945, a 4-cm-long piece was sawn out from the upper part of the left femur. Fixation of the fragment through a marrow-nailing. The piece of bone which had been taken from the left femur, intended to be used for lengthening of the right leg, was now left to remain between the bone and the muscles fixed to the periosteum (Fig. 11).

We dared not, at this same time, make intraplantation on the right side, fearing that this would be too much of a strain on the patient, and the double nailing would also have increased the risks for fat embolism. On October 3, a new operation with intraplantation of the piece from the left femur into the upper part of the right femur was undertaken (Fig. 12). As it was not possible to pull the bone pieces sufficiently apart to permit the insertion of the entire 4-cm-long bone piece, 1 cm had to be sawn out. The lengthening was, therefore, only 3 cm. Through these operations the difference between the legs was reduced from 18 to 11 cm. The healing progressed satisfactorily, and, already, four weeks after the last operation, the patient was allowed to rest on her left leg, and after four more weeks she was able to bear weight on her legs. We are thinking of making a similar operation upon the lower part of her legs after six months or a



FIG. 11—Case 14. Showing the type of congenital deformity.

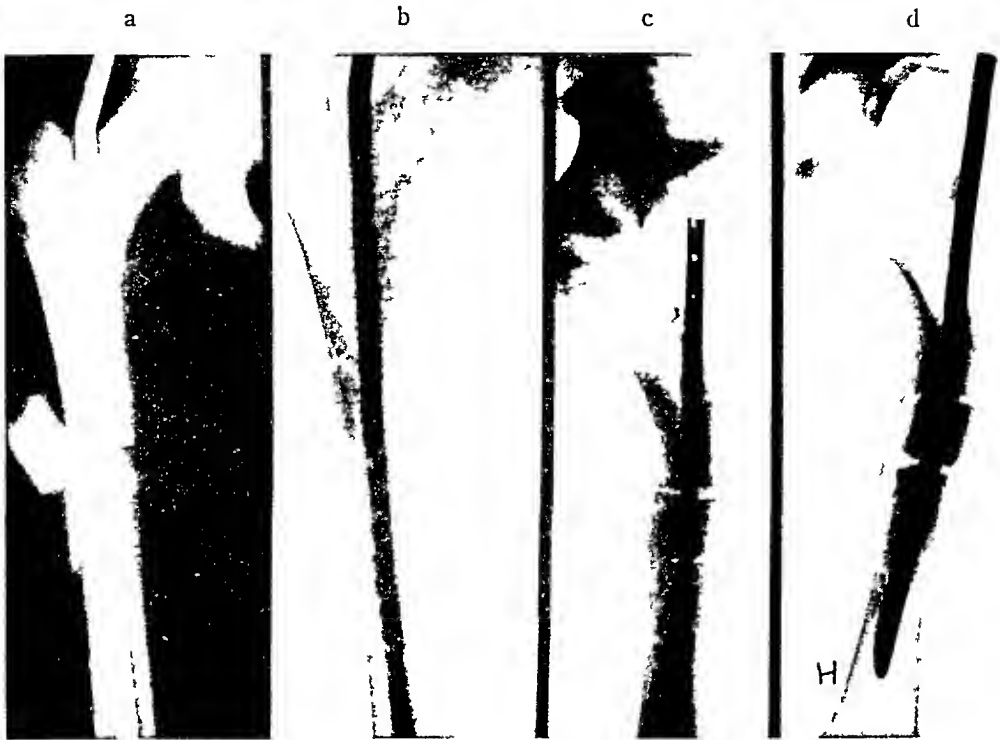


FIG 12—Case 14 (a) Resection of 4 cm of the left femur (b) Left femur six months later (c) Intraplantation of a 3-cm-long piece from the left femur (d) Four months later

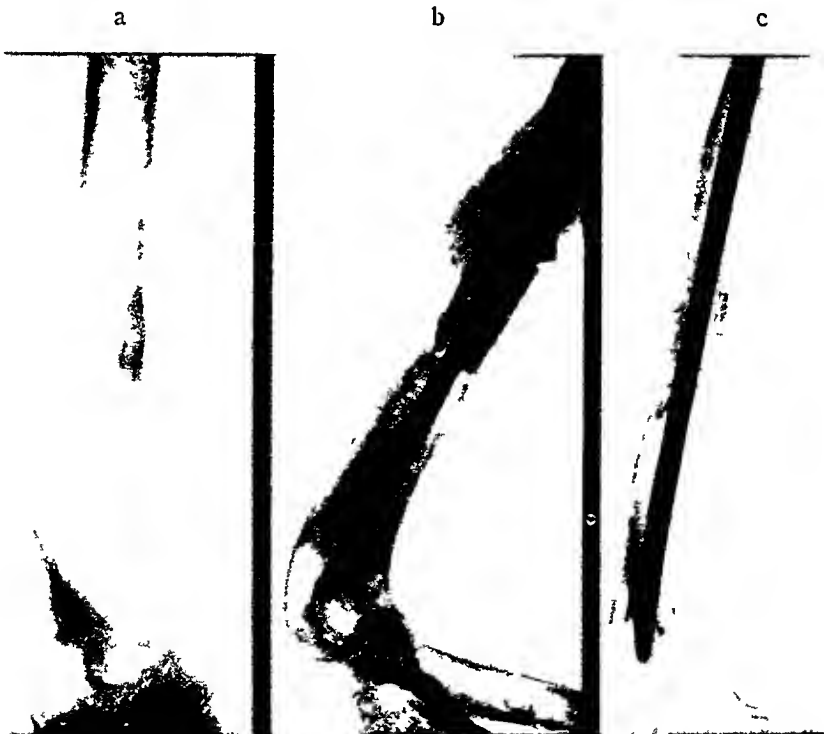


FIG 13—Case 15 (a) Defect pseudarthrosis of the humerus (b) After bone transplantation and marrow-nailing (c) Five months later

year. Then the difference in the length of her legs would only be 5-6 cm. After a possible third operation her legs might become of equal length.*

Case 15—Finnish soldier, age 29. After shell injury, August 5, 1944, prolonged suppuration and loosening of bone splints. When he entered the Sahlgrenska Hospital in August, 1945, the wound had been healed for two months. Roentgenograms showed a defect pseudarthrosis, with more than 5 cm distance between the bone ends.

Operation—August 30, 1945. After excision of all fibrous tissue and freshening of the bone ends, a 25-cm-long marrow-nail was driven into the bone marrow. The bone defect was filled out by means of a 6-cm-long piece of one of the fibulae. Very firm fixation resulted. A mild suppuration arose which soon ceased after penicillin treatment. Roentgenogram, in January, 1946, shows that the bone piece is healing in (Fig. 13).

CONCLUSIONS

In conclusion, I should like to express my opinion that *medullary-nailing constitutes a very great advance for recent fractures, as well as for pseudarthrosis and bone plastic*. In the treatment of fractures it can already, now, be said that this so-called "*stable osteosynthesis*" is in many ways superior to the old methods of treatment, particularly, the old forms of osteosynthesis. In my opinion, it will involve an equally great revolution in the treatment of fractures in the femoral diaphysis, as the method of nailing in the femoral neck did to the treatment of these fractures. In cases of pseudarthrosis and bone plastics marrow-nailings give such a firm fixation of the bone pieces that their healing in is made considerably easier. As plaster need not often be applied, stiff joints are avoided in several cases.

*In 1946 we did a new similar transplantation and the difference in the length of her legs is now 8 cm.

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CARDIAC RESUSCITATION

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SUDDEN CESSATION of cardiac activity is an emergency, the recognition and treatment of which are poorly understood by many surgeons. Inadequacy of management of this catastrophe is common in the practice of general surgery, but even more so in the surgical specialties in which resuscitation is rarely achieved. Prompt diagnosis, courageous decision and intervention based on a rehearsed plan of action can prevent fatalities which at the moment seem inevitable. Experience with four patients in whom cardiac arrest occurred, and in whom restoration of the heart beat was accomplished leads us to re-emphasize the teachings of such pioneers as Bailey¹,² Beck,³ Wiggers⁴ and others who have stressed the basic principles on which treatment is founded.

Two problems demand attention. The heart beat must be restarted, and the central nervous system must not be deprived of oxygenated blood for more than three or four minutes. Cerebral anemia of greater duration is followed by widespread cerebral cortical destruction and death. This sequence of events occurred in two of our patients. The other two patients were returned to normal health.

DIAGNOSIS

The primary cause of failure in cardiac resuscitation is delay in diagnosis. During intrathoracic operations the heart can be directly visualized and recognition of cardiac inactivity is easy. If a major artery such as the aorta, the carotid, brachial or femoral can be inspected or palpated through the operative wound the status of the heart beat can also be readily determined. Under other circumstances, however, when no peripheral pulse is palpable and blood pressure cannot be obtained by auscultation, three possibilities must be considered: (1) the heart has stopped beating entirely, (2) the ventricles are fibrillating or (3) cardiac contractions are so feeble that insufficient blood is ejected to raise arterial pressure to the level at which a peripheral pulse can be felt. The majority of patients are doomed because minutes which cannot be spared are wasted in searching for a stethoscope, in frantic palpation of a succession of arteries, in hasty consultation with colleagues summoned to judge a situation with which they are unfamiliar.

The only certain method of ascertaining whether the heart is still beating is to palpate or visualize the heart or large arteries directly. A second, less

dependable procedure, is to visualize the retinal vessels through an ophthalmoscope (in the absence of cardiac contractions the retinal arteries will not be visible (5) and the column of blood in the veins will be broken up into short segments) The electrocardiographic tracing unfortunately cannot be relied upon The work of Negovski indicates that at the time of cardiac arrest the heart current can still (6) produce for some time an electrocardiogram with deviations from the normal The absence of capillary refill is strong evidence that the circulation has stopped but may be difficult to evaluate particularly in dark skinned individuals

The implications of the above are clear Opening the thorax is the only conclusive *diagnostic* procedure If the heart has stopped or the ventricles are fibrillating minutes can be saved by adopting the attitude of rapidly opening the chest for diagnosis, whereas if the heart is beating feebly little harm may have been done

TREATMENT

Artificial ventilation of the lungs with 100 per cent oxygen and cardiac massage are the essentials of therapy.

The method of artificial respiration depends upon the circumstances If cardiac arrest has occurred in the operating room, an anesthesia machine is satisfactory Manual compression of the breathing bag will inflate the lungs and the elastic recoil of the respiratory organs completes the cycle If resuscitation is attempted elsewhere the bag and mask technic⁷ or the Kreiselman "bellows" resuscitator⁸ are simple and effective One should guard against excessive intrapulmonary pressures since such pressures will reduce venous return to the heart by blocking blood flow through the lungs^{9, 10}

Although respiration (normal or artificial) can cause some blood to circulate, the most effective mechanism for movement of blood is the pumping action of a contracting heart In the absence of spontaneous cardiac activity manual compression of the ventricles will provide sufficient circulation to maintain the integrity of the central nervous system until rhythmic cardiac contractions are re-established Adequate exposure of the heart is therefore essential and must be obtained at the earliest possible moment

A transverse incision in the fourth left intercostal space is best The fourth and fifth ribs can readily be spread apart and the heart grasped by the operator Exposure may be increased by dividing the fourth and fifth costal cartilages A direct approach through the chest wall is superior to an abdominal incision with an attempt to reach the heart through either an intact or an incised diaphragm Opening of the pericardium is not required

The heart is compressed firmly at the rate of 20-40 times per minute, depending upon the adequacy with which the ventricles fill between compressions Each compression raises arterial pressure 60-70 mm Hg and a pulse can often be felt in a peripheral vessel To increase blood flow through the coronary arteries the aorta may be occasionally compressed just above these vessels⁴

The role of epinephrine in cardiac resuscitation is uncertain. In the experimental laboratory when cardiac action has ceased it is common practice to inject this potent cardiac stimulant into the heart chamber, massage the heart and achieve a successful result. Theoretical objections to the drug exist, however, since increased myocardial irritability and the development of ventricular fibrillation are known to follow its administration. If epinephrine is to be used, it should be placed into the auricle rather than the ventricle. This confines any abnormal stimulus (chemical or mechanical) to a chamber in which fibrillation is of little significance.

Ventricular fibrillation If circulatory collapse is due to fibrillation of the ventricles rather than to complete cessation of cardiac activity, a different type of therapy must be employed.

The most effective method of treatment is the technic of serial defibrillation developed by Wiggers.⁴ An electric current of 10 ampere (60 cycle) is passed through two brass discs 2-3 inches in diameter which are applied to the sides of the heart. Each shock lasts less than one second, 1-2 seconds elapse between shocks, 3-7 shocks as a rule suffice. Wiggers' plan is to merge small fibrillating areas into larger ones, and then stop the entire fibrillation process with one final electric shock. Electrodes can be kept sterile in operating rooms, and application is simple once the heart is exposed. Before counter shocks are thrown into the heart, it should be manually compressed for 30-60 seconds. This provides blood for the myocardium and may improve the chance of recovery. Countershock therapy is successful in a high percentage of instances. Once fibrillation has ceased, of course, one is again faced with the problem of re-starting rhythmic cardiac activity.

The use of procaine to prevent fibrillation and to treat it once it has developed has been suggested. There is no doubt that procaine raises the threshold of the heart to fibrillation produced by epinephrine.^{11, 12, 13} It has also been shown that the intravenous or intracardiac injection of procaine into anesthetized dogs which have developed cardiac arrhythmias with a shift of the pacemaker has caused a return of the pacemaker to the sinus node.¹⁴ Finally, during cardiac surgery in World War II experience was gained which suggested that results on animals might be applicable to man. Burstern¹⁵ injected single doses of 30-70 mg procaine intravenously into 14 anesthetized patients with acute arrhythmias occurring during intrathoracic surgery. No untoward effects on the nervous system, respiration or circulation were observed. The dysrhythmias always improved, often dramatically. Wiggers¹³ on the other hand, although admitting that procaine raises the fibrillation threshold of the ventricle, states that the drug is not a preventive and believes that it is unwise to use depressants such as local anesthetic agents, or to attempt to modify conduction. Stutzman *et al*¹⁶ also were unable to reverse ventricular fibrillation with intravenous or intracardiac injections of procaine made within 30 seconds of the onset of the fibrillation. The question is therefore not settled and further work must be done to evaluate the myocardial

depressant action of this local anesthetic. It must be realized that the intravenous injection of procaine without cardiac massage can accomplish nothing if the ventricles are fibrillating, since the drug cannot reach the heart.

Adjunctive therapy Successful cardiac resuscitation usually leaves one with a patient who is unconscious for a certain period of time. Such a patient must receive constant care if secondary complications are to be avoided. Secretions which accumulate in the pharynx and tracheobronchial tree must be aspirated. Prophylactic injections of penicillin are often advisable to minimize pulmonary infection. The patient must be turned frequently from side to side to avoid hypostatic congestion in the dependent portions of the lungs. Urinary output must be maintained by an adequate fluid intake, and constant attention must be paid to the bladder. Inhalation of oxygen is employed, although it is uncertain whether this is helpful in the presence of a normal arterial oxygen saturation. Blood volume and hematocrit determinations are of value in deciding whether blood or plasma transfusions should be used. All of these measures were used in the management of the patients reported in this paper.

PROGNOSIS

1. What is the likelihood that the heart can be started again?

The heart is an amazingly resistant organ, possessing rhythmicity and contractility which are difficult to destroy. Kountz¹⁷ studied the hearts of individuals who had died five minutes to six hours prior to his examination. By perfusing the coronary arteries he was able to revive 58 of 127 hearts. Forty-eight of these beat rhythmically for at least two hours. Of 34 hearts which he observed within 30 minutes after death, 24 were revived. Of 29 others studied within 30-60 minutes, 17 resumed regular contractions. He was able to restore only four of the 20 hearts perfused five to six hours postmortem.

Whether the heart can be made to beat again regularly, and whether this activity can be maintained depends upon the age of the patient, the cardiac status prior to the catastrophe and the cause of the cardiac arrest. Young, healthy hearts can be restored to normalcy with relative ease, but a myocardium damaged by toxemia, arteriosclerosis, hypertension, coronary insufficiency, or narcosis is much less likely to recover.

In general, if prompt diagnosis is followed by prompt therapy, the heart can be started again. If, on the other hand, there is hesitancy rather than boldness, or if intravenous therapy is attempted before attention is directed towards the heart, the myocardium may have been sufficiently damaged by anoxia to resist all efforts at resuscitation.

2. If the circulation is restored, what will be the status of the patient's central nervous system?

When the heart returns to a regular rhythm, and blood pressure is maintained, spontaneous respiratory activity can be expected to reappear within 5 to 30 minutes. This indicates that medullary cells are the most resistant

in the central nervous system, a fact clearly established by many investigators. This also illustrates the fact that in the medulla itself the vasomotor center is more resistant than the respiratory center.

Once vital functions have been restored, two possibilities exist. (1) The patient may steadily improve until consciousness is regained and a partial or complete recovery is made. Unless the period of circulatory cessation has not exceeded two to three minutes the postoperative course is stormy. Or (2) consciousness is never regained and death occurs. The heart may again cease to beat within a few minutes or hours, or the fatality may be delayed for weeks (26 days in one case reported in England¹⁸).

The duration of cerebral anoxia determines the prognosis. Quantitative data are not available for man, but the work of Weinberger, Gibbon & Gibbon⁵ in cats, gives an index of the ability of the mammalian central nervous system to withstand complete deprivation of blood supply. These investigators clamped off the pulmonary artery suddenly stopping blood flow throughout the body. The clamp was released at various times and the degree of recovery was correlated as follows:

<i>Duration of Circulatory Arrest</i>	<i>Recovery</i>
1 2 min to 3 min 10 sec	Complete within 24 hours
2 3½ min to 5¼ min	Wildly excitable for 24 hours, gradual improvement until at end of one week there remained only alterations in behavior and loss of normal intelligence
3 6 min to 7¾ min	Only three of nine animals survived. The typical picture was that of hyperactivity and wild purposeless behavior, followed by stupor or indifference to stimuli. The cortex suffered irreparable damage. There was blindness, spasticity and dementia. The animals who survived were little more than reflex mechanisms.
4 8¾ min to 10¼ min	All seven animals in this group died within 75 minutes to 48 hours of the circulatory arrest. Coma, alternating with convulsions, was characteristic of the brief survival period.

Certain factors may increase the resistance to anoxia. For example, anesthesia may protect by depressing cellular activity, and reducing the demand for oxygen per unit of time. This has been demonstrated by Rosenthal, Shenkin and Drabkin¹⁹ in carbon monoxide poisoning in which 75 per cent carbonyl hemoglobin was found to be the critical level for *unanesthetized* dogs. Lesions of the brain were always seen in dogs kept for brief periods under these conditions. Dogs under light surgical anesthesia with nembutal, however, survived, without ill effects, acute carbon monoxide hypoxia at levels as high as 85 per cent (and in one instance 93 per cent) of HbCO in the blood. Furthermore, if cardiac arrest occurs during the course of closed system anesthesia and high oxygen concentrations have been used, the extra oxygen dissolved in the plasma may prolong survival of the central nervous system.

CASE REPORTS

Case 1—A S., a 51-year-old Negro male, had a toxic nodular goiter for at least five years prior to admission. For three years he had had auricular fibrillation and, because of thyrocardiac symptoms, was a virtual invalid. Repeated courses of iodine and thiouracil resulted in incomplete remissions but he refused operation until the present admission. During the period of preoperative preparation he was digitalized, and gained weight satisfactorily. The risk of operation was not considered unusually great.

On 3/3/47, the morning of operation, he was given morphine 10 mg., scopolamine hydrobromide 0.3 mg., and atropine sulphate 0.4 mg. at 7:30 A.M. At 7:50 A.M., 10 cc. of a 5 per cent solution of pentothal were administered rapidly and an endotracheal tube was inserted. Anesthesia was maintained with a slow drip of 1 per cent pentothal sodium and inhalation of a 70 per cent nitrous oxide, 30 per cent oxygen mixture through a partially closed system. During the first 25 minutes of the operation the surgeons thought the blood was abnormally dark. The anesthetist did not believe it was darker than normal venous blood and considered that there was no evidence in the pulse rate or blood pressure of oxygen deficit. Substitution of cyclopropane for nitrous oxide resulted in a much lighter color of the blood. The blood pressure promptly rose from 140/80, which it had been since the beginning of the operation, to 210/90, then to 230/90, and the pulse became more irregular. With resumption of the nitrous oxide-oxygen mixture the blood again became dark and the blood pressure gradually fell, during the next 15 minutes, to 110/80, with a pulse rate of 78.

Fifty-five minutes after the operation was begun the temporal pulse, which was being constantly palpated, suddenly disappeared. This occurred between 8:59 and 9:00 A.M. Approximately 4 minutes later the chest was opened and the diagnosis of cardiac arrest was confirmed. After thirty seconds of cardiac massage the heart began to beat spontaneously and the blood pressure was 100/70. One minute later the ventricles began to fibrillate and the heart was again massaged. Two cc. of 1 per cent procaine were injected into the pericardium and 3 cc. into the right ventricle. Bronze disc electrodes were applied to the heart and after the third electrical shock (2 amp) which caused a violent spasm of the entire body, ventricular fibrillation stopped and normal spontaneous ventricular rhythm resumed (9:15 A.M.) although the auricles continued to fibrillate. Less than one minute later spontaneous respirations (24-30 per minute) began and the blood pressure was 140/80. Resection of the right lobe had just been completed when cardiac arrest occurred. The wound was quickly closed. The total dosage of 1 per cent pentothal sodium was 65 cc.

At 9:37 A.M. a swallowing reflex was noted and at 10:30 A.M., during tracheo-bronchial toilet and removal of the endotracheal tube, the cough reflex appeared quite active. The pupils were quite small and reacted sluggishly to light.

After resumption of spontaneous cardiac activity the pulse rate and blood pressure remained remarkably constant, the pulse ranging from 80 to 110, and the blood pressure from 120/80 to 110/95. At 11 A.M. the rectal temperature was 102° F. Fearing hyperthermia, an ice pack was applied from toes to chest. This soon caused violent shivering and peripheral cyanosis, but reduced the temperature to 99° F. Whenever the rectal temperature rose to 103° F. ice was reapplied and this was always accompanied by shivering and cyanosis. The repeated use of ice packs was effective in keeping the rectal temperature below 104.5° F.

An electrocardiogram at 11 A.M. showed a right bundle branch block, with inverted P waves in leads 2 and 3, and in all chest leads. At 12:45 A.M. another electrocardiogram showed frequent auricular extra systoles, and almost complete disappearance of the bundle branch block. The T waves were upright in the limb and chest leads.

On neurologic examination at 12:30 P.M. there was no spasticity but all deep reflexes were hyperactive, and there were positive Hoffman and Troemmer reflexes. Plantar responses were neutral, abdominal reflexes were absent, and there was no clonus.

At 7 00 P M brief clonic convulsions involving both lower extremities began and an hour later there were violent, generalized clonic convulsions. These continued to occur at frequent intervals, ranging from a few seconds to several minutes in duration. The cerebral spinal fluid pressure was normal and the fluid was clear. About midnight Cheyne-Stokes respirations were noted and thereafter recurred at frequent intervals.

During the next four days the picture remained essentially the same, *ie*, a comatose patient, with intermittent generalized clonic convulsions and Cheyne-Stokes respirations. The pupils reacted sluggishly to light. At times a corneal reflex was noted and on a few occasions pressure on the supraorbital nerves resulted in slight movement of the right arm. Accumulation of tracheobronchial secretions required more and more frequent aspirations. One millions units of penicillin daily were given prophylactically. Fluids, electrolytes, and vitamins were given parenterally and the urinary output was more than 1500 cc daily. On the night of the fourth postoperative day he was obviously moribund and death occurred at 10 30 A M on 3/8/47.

Case 2—B A, a 21-year-old female with gangrenous appendicitis. An appendectomy was begun at 1 30 A M, 4/4/46 under procaine-pontocaine spinal anesthesia. This patient weighed 190 lbs and was only 5'1" tall. Her sensory level of anesthesia rose rapidly to the sixth cervical dermatome. This was accompanied by inability to talk, respiratory depression and finally acute circulatory failure, with no obtainable blood pressure. The full significance of the situation was not appreciated by the anesthetist for a few minutes at least, so that it is difficult to determine the exact duration of cardiac arrest with certainty. This is estimated at six to eight minutes at a minimum. Therapy consisted of an intracardiac injection of desoxephedrine, and artificial ventilation with 100 per cent oxygen. Cardiac massage through the diaphragm was then instituted and continued for eight minutes before spontaneous cardiac contractions began. With each cardiac compression an impulse could be palpated in the radial artery. With the return of rhythmic action the blood pressure was 102/80, pulse rate 120. Spontaneous respiration was noted in 30 minutes. Soon after breathing was re-established twitching of the arms and legs commenced. The operation was completed at 3 A M. Blood pressure at the end of the operation was 80/50, pulse 140.

Four hours postoperatively rectal temperature had risen to 108° F and the twitchings described above had progressed to severe convulsive movements of the entire body. Ice water sponges and ice water enemas together with sodium luminal 60 mg intramuscularly were administered and an electric fan was set up to blow over the patient's body. The twitchings were reduced in frequency and intensity and the temperature fell to 102° F. At this point the patient responded to painful stimuli by moaning and by moving her extremities.

At the sixth postoperative hour the blood pressure was 70/50, temperature 104° F and the patient was given 150 cc of 50 per cent glucose by vein. This was administered in an attempt to decrease the cerebral edema thought to be present following severe anoxia whether by coincidence or on a cause-effect relationship. The response to this therapy was dramatic. The patient became much quieter, the temperature fell to 99° F, the pulse rate fell from 120 to 80 per minute and the blood pressure rose to 114/58. The general appearance was more that of sleep. At the eighth postoperative hour projectile vomiting began and the patient moaned and moved about in bed. Neurologic examination at this time revealed a positive Babinski reflex on the right side, frequent contractions of the extremities, eye balls rolled up, pupils reacting to light. Twelve hours postoperatively it appeared as though the patient might recover. She seemed only semistuporous and responded to her name. Considerable difficulty was had in maintaining an adequate blood pressure and for the greater part of this first postoperative day her blood pressure ranged between 70 and 90 mm Hg systolic. The usual anti-shock measures were employed. Estimates of plasma volume at this time indicated a volume of

3200 cc which was about 500 cc below her supposed normal. An hematocrit of 33 per cent was obtained.

The next problem which presented itself was that of mucus in the tracheobronchial tree. Frequent aspiration was necessary and finally an endotracheal tube was inserted and considerable amounts of blood-stained mucus were aspirated frequently. The patient's color remained good, vital signs were adequate and because of her apparent response to relatively slight stimuli it was felt that she would survive. A neurologic examination made 12 hours postoperatively (Dr A. M. Ornsteen) was reported as follows: "Sensorium clouded, mildly reactive to pain stimulus, blinking active with eyes open, probably not conscious of light stimuli. Pupils 3 Mm react well and equally. Fundi normal. Trismus, neck free, general flexor spasm of distal portion of limbs. Spinal reflexes of defense marked. Fragmentary tonic neck reflex, as head moved to right the right arm came up, no pathologic reflexes. The present picture is that of mesencephalic edema, secondary stasis and perivascular diapedesis."

During the next 24 hours the patient became less reactive. She responded less to stimuli. At the same time it was evident that despite frequent tracheal aspirations there were many coarse rales which remained in the larger bronchi. She was bronchoscoped and thoroughly aspirated. In spite of an adequate fluid intake urine volume was small.

Cyanosis and labored respiration were first noted 48 hours postoperatively. This was associated with a sudden decrease in blood pressure and with spasticity and convulsive seizures. The rectal temperature, which had been slowly rising, reached 106° F. It became obvious that serious cerebral damage had occurred and that if the patient survived she would be decerebrate. She was in deep coma. During the remainder of her course she had recurring bouts of cyanosis, labored respiration and hypotension. She died of pulmonary edema 64 hours postoperatively. Autopsy revealed pulmonary edema as the only gross finding.

Case 3—M. L., age 20, with mediastinal tumor. An exploratory thoracotomy was planned, and anesthesia with cyclopropane-oxygen was begun at 12 50 P.M., 6/1/45. Because of a gross overdose of the anesthetic agent, or as the result of an inhibitory reflex secondary to endotracheal intubation,²² heart action ceased at 1 01 P.M. One cc of 1:1000 epinephrine was injected into the right ventricle and 100 per cent oxygen was administered through the endotracheal tube. Since epinephrine caused no response, the patient was moved into the operating room, the thorax was opened under aseptic technic and cardiac massage of a motionless, flabby heart was begun at 1 06 P.M. Feeble contractions were noted after the third compression. Once started this cardiac activity increased steadily in vigor until full rhythmic beats were evident. Blood pressure rose to 140/100. Spontaneous respiration was noted 25 minutes after the heart started to beat again.

At 2 15 P.M. limb reflexes were hyperactive but no abnormal reflexes were elicited. The patient moaned occasionally and moved her extremities about aimlessly. At 3 45 P.M. twitching of the limbs was first noted. These spasms, brief at first, progressed in severity and duration until at 4 15 P.M. there were rapidly recurring tonic bouts of rigidity involving the entire body. These episodes which lasted 60 to 90 seconds could be initiated by even the slightest stimulus. By 5 30 P.M. the rigidity was less intense and spasms occurred less frequently. At 7 00 P.M. some of the patient's movements appeared purposeful. She was no longer comatose, but was in a state of semi-coma.

By 9 00 P.M. the spasms of rigidity had almost ceased. In their place there occurred violent muscular activity in response to such stimuli as extension of the arm. Restlessness was marked and restraints were necessary. At 12 00 midnight the patient looked and acted like a wounded animal, screaming aloud, incoherently, and thrashing around in bed. Blood pressure was 120/96, pulse 108, respiratory rate 24, rectal temperature 101° F. Bouts of extreme activity alternated with periods of deep sleep. After each of

these rest periods she seemed on the verge of talking and could squeeze one's hand in response to a command. By 4 00 A M she was less restless and responded less violently to stimuli. Her fingers were held as though in tetany, or parkinsonism. Her arms were folded across her chest. At 8 00 A M she opened her eyes and at 9 00 A M spoke her name distinctly. She continued to sleep for the majority of the time.

At 2 00 P M, 6/2/45, a neurologic examination (Dr A M Ornsteen) was reported as follows: "The patient is somnolent. When aroused she co-operates well, attention is only fair, apperception poor. She localizes physical distress well. Left arm less used in gestures. Neither arm or either leg can be held up well. The upper extremities drift down, left more than right. Lower extremities not held up at all. Extraocular movements normal, no nystagmus, pupils normal, react to light, fundi negative. Hand grips are good considering the circumstances. Left ankle jerk is weak, right ankle jerk absent. Neither knee jerk obtained. Arm jerks present, right greater than left, normal plantar reflexes. No abdominal reflexes. Dysarthric but not aphasic." Mental confusion persisted. There were periods of complete irrationality and marked restlessness succeeded by profound exhaustion and deep sleep. When awake she spoke distinctly but with hesitation. She recognized her family and called them by their proper names.

June 3, 1945. The patient carried on an intelligent conversation but had retrograde amnesia and appeared euphoric. Twelve hours later this mental attitude was replaced by one of antagonism.

June 4, 1945. She was oriented for the first time, knew where she was but had no idea of recent past events.

June 5, 1945. Completely rational during the day, but at night she was seized with vivid hallucinations and episodes of disorientation. She was up in a wheel chair and although weak, she exhibited good motor control.

June 6, 1945. Began to recall events before her operation, knew for the first time where she was and why she was there.

June 8, 1945. Much clearer mentally, but very tired and irritable.

June 11, 1945. Neurologic examination was entirely negative. "No cerebellar or dysarthric signs. No subjective complaints. Extraocular movements normal, no nystagmus. No cranial nerve changes. Plantar reflexes normal. Mental status now normal. Consider her fully recovered." The patient was discharged on June 22, 1945. On September 19, 1945, a right pneumonectomy was performed by one of us (W H E) and a malignant tumor of the right upper lobe was removed. Anesthesia and surgery progressed uneventfully on this occasion. A follow-up report on June 25, 1946, indicated that metastases had occurred and the patient was losing weight steadily. Mentally she continued to be normal.

Case 4—Chao Da Thea, a 22-year-old Chinese soldier, was given a right brachial plexus block at 8 10 A M, February 9, 1944. A supraclavicular approach was used. Aspiration before injection of the local anesthesia produced no blood. During a four-minute period 16 cc of 2 per cent metycaine in water with epinephrine were deposited over the trunks of the brachial plexus. At 8 14 A M the injection was stopped because the patient began to retch. Cyanosis of the lips was noted. Blood pressure was 120/60, pulse rate 108. One hundred per cent oxygen was administered by a B L B face mask.

At 8 20 A M the pulse was still palpable. Two cc of a 5 per cent solution of pentothal were injected intravenously. At 8 21 A M respiration ceased, nor could pulse or blood pressure be obtained. The lungs were artificially inflated with oxygen from an anesthesia machine. At 8 22 A M the heart was first examined with a stethoscope and no sounds were audible.

The chest was hastily prepared for an incision in the 5th left interspace. The heart was exposed at 8 25 A M. It was in standstill. Artificial systole was begun manually. Rhythmic contractions appeared after 60 seconds of this therapy. At 8 40 A M spon-

taneous respiratory activity was noted, and 5 minutes later the patient began to move about on the operating table. The thoracotomy incision was closed at 8 55 A M, at which time the patient was thrashing around wildly and groaning aloud.

For the next hour and one half, the patient exhibited the clinical picture of cerebral irritability resulting from acute hypoxia. He was manic and showed bizarre neurologic phenomena—atypical opisthotonos and spasticity of the flexor muscle groups. There was a rhythmic pattern to the convulsive activity, two or three minutes of wild excitement and generalized muscular rigidity being followed by moments of quiet and relaxation. Oxygen was administered intermittently throughout this period.

Ten cc of a 5 per cent pentothal solution were administered intravenously from 10 20 to 10 30 A M in an attempt to control the hyperkinetic activity with light narcosis. At 11 00 A M the effects of this had largely disappeared. During the next four hours, the patient's general condition remained the same. There were alternating periods of motor restlessness and spasticity and quiet. He began to respond to external stimuli by opening his eyes. No hyperthermia developed. By 8 00 P M he had recovered consciousness and answered questions. He was still obviously confused. Rectal temperature was 100.3° F. The circulation was normal.

By the following morning, he had made a complete recovery, and there were no sequelae of any kind. Recovery was uneventful. The patient got out of bed on his fourth postoperative day. He was seen again six months later and was found to be completely normal.

COMMENT

The causes of cardiac arrest in the four patients discussed above were varied. In Case 1 many factors require consideration. Cardiac damage was already present preoperatively. Digitalis had been administered. This drug *per se* is believed to increase myocardial irritability. Anoxia was evident during part of the surgical procedure. The sudden rise in blood pressure ten minutes before the catastrophe may have placed a great load on the heart. Finally, the possibility of vagal reflexes arising as the result of manipulation around the thyroid gland should be mentioned. In all probability the combination of increased work, decreased oxygen supply, and increased irritability proved too much for a thyrotoxic heart.

In Case 2, a so-called total spinal anesthesia was unfortunately achieved. Paralysis of the muscles of respiration occurred together with a sharp reduction in blood pressure. Decreased coronary blood flow, and a diminished venous return of such magnitude that the heart muscle had little against which to contract would seem sufficient explanation for cardiac failure under these circumstances. In Case 3 an overdose of the anesthetic agent, or cardio-inhibitory reflexes secondary to endotracheal intubation were probably responsible for cardiac arrest in an otherwise normal, young girl. In Case 4 one can postulate idiosyncrasy to the local anesthetic agent, or, more likely, inadvertent intravenous injection or rapid absorption of the drug. The depressant action of even a small dose of pentothal under these circumstances may have been contributory.

Faced with a heart which was not beating, the anesthetists and surgeons in each instance reacted with what might appear to be reasonable promptness. Cardiac massage was instituted and restoration of the heart beat was accomplished. "Reasonable promptness," however, was inadequate, for only two

of the patients made complete recoveries. In Cases 1 and 2 the delay of five to eight minutes before the heart was manually compressed was followed by irreversible anoxic changes in the cerebral cortex. The margin between a successful outcome and a fatality is indeed slim as these four experiences indicate.

If cessation of cardiac activity has been brief, convalescence may be indistinguishable from that seen in the average surgical patient, as illustrated by case reports of Lium²⁰ and Adams and Hand.²¹ If the duration of cerebral anoxia has been slightly more prolonged, convalescence may be stormy, but with indications of steady improvement as each hour passes (Cases 3 and 4). Cases 1 and 2 on the other hand, are examples of the tragic decline of an organism which has suffered irreversible changes.

Acute febrile responses (102° – 108° F), manifestations of cerebral cortical irritability (muscular rigidity, twitching, convulsions, hyperflexia) and varying degrees of coma are characteristic. The time of onset and the duration of these phenomena are of interest since analysis of such data may permit prediction of the outcome of a particular case. Our experiences indicate that recovery can be predicted on the basis of events occurring within the first 12 hours. Persistence of coma beyond this period is unfavorable. It is to be hoped that this type of patient will be more accurately observed in the future, particularly from the neurologic standpoint. Much information of value can be obtained from such studies.

Certain problems raised in this paper demand investigation. It is apparent that the brain is the most vulnerable of all body tissues as far as oxygen deficit is concerned. Is there any means of protecting this organ preoperatively? Can a reserve of glucose, enzymes, vitamins or other essential elements be built up in the same way as the liver is protected by preoperative therapy? If this is impossible, can the need of the brain for oxygen and nutritive material be safely reduced in some way during operation so that in an emergency the time of survival of the central nervous system may be prolonged? Finally, since time is so important, should attention be directed at once towards perfusing the brain via the carotid arterial system before any other therapeutic efforts are made? Of the measures commonly adopted during the management of cardiac arrest epinephrine and procaine require further critical study. Both have clinical and experimental evidence suggesting their utility, yet theoretical objections to each are strong. The status of intra-arterial^{23, 24} and intracardiac²⁵ infusions must also be defined. By immediately raising pressure throughout the arterial tree the former has distinct advantages over the intravenous route for administration of fluid and by providing a volume of fluid against which the ventricles can contract the latter may be useful.

Above all, however, is the necessity for a greater awareness of the possibility of cardiac arrest on the part of anesthetists and surgeons. Resumption of normal cardiac activity must be the first consideration, when deterioration of a patient's condition becomes evident.

SUMMARY

Prompt diagnosis and prompt therapy are essential for cardiac resuscitation. Treatment must be boldly executed according to a carefully worked out plan, consisting primarily of artificial respiration with 100 per cent oxygen and cardiac massage. The success or failure of such a program depends entirely on the length of time that the brain is without blood supply. If restoration of the circulation occurs within three to five minutes complete recovery can be expected, particularly in young, previously healthy individuals. If much more time than this elapses before resuscitation, permanent cerebral damage will occur. The course of four patients in whom cardiac resuscitation was successful is described.

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METABOLIC STUDY OF BURN CASES

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THE WORK TO BE DESCRIBED, which was the subject of a preliminary communication,¹ had as its principal object a complete study of the nitrogen balance of burned patients, including the loss of protein in the exudation from the burned area. For a time, however, ward facilities were not reliable for accurate metabolic work, and attention was therefore directed to simple determination of the nitrogen in the urine, measurement of the creatinine and creatine excretion, plasma protein estimations, and so on. While some of that work has been useful, it is unfortunate that many of the early figures obtained had to be disregarded, as examination of the ward records showed that no reliance could be placed on the collections of urine being complete or on their having covered the stated periods of collection. As stated in the preliminary note, this trouble was largely due to shortage of trained staff, and it is part of the purpose of this report to draw attention to the absolute necessity for the collection of specimens to be under the supervision of a reliable, responsible person, if the laboratory work in such metabolic investigations is not to be vitiated.

In certain cases, although the urine specimens were clearly not accurate 24-hour collections, it is possible to give a figure for the average daily nitrogen excretion over a period, as little or none appeared to have been lost.

Since then we were fortunate in securing the services of Nurse L. Thrusell for a short time (by the kindness of Professor R. A. McCance) and, more recently, of Sister R. M. Selley, they have looked after the patients on whom nitrogen balances were carried out and have supervised the feeding and the collection of specimens in these cases.

The report is divided into the following sections:

- 1 Urinary nitrogen excretion
- 2 Nitrogen balances
- 3 Nitrogen in the exudate from the burned area
- 4 Plasma proteins
- 5 Creatinine and creatine excretion
- 6 Proteinuria
- 7 Chloride excretion and plasma chloride level
- 8 Blood sugar levels

It was hoped to do some work on the nitrogen partition of blood and plasma and urine, in view of the large undetermined nitrogen values reported by some of the American workers,^{2, 3} but unfortunately pressure of work prevented this.

The results of liver function tests in many of these cases are to be published by Mr. Garfield Thomas.

METHODS

Urine was collected in bottles with chloroform, or a 5 per cent solution of thymol in chloroform, as preservative

Total nitrogen in urine was determined by the Kjeldahl method. Checks were carried out at intervals with solutions of pure urea, when theoretical recoveries were always obtained

Feces were not usually tested, the fecal nitrogen generally being taken as one-ninth of that in the urine

Exudate The exudate was collected in Cellucotton or wool, the dressings being covered with washed,* sterilised Cellophane placed immediately under the ciêpe pressure bandages to minimize leakage.** The nitrogen in the dressings was determined by boiling them with 10 per cent sulfuric acid and taking a sample of the mixture for Kjeldahl digestion. It was found necessary to keep the disintegrated dressings vigorously stirred in order to prevent bumping; this stirring has the further advantage of breaking up the dressings and assisting in the formation of a uniform mixture. A blank value for dressings and reagents was obtained by treating in the same way an approximately equal quantity of the materials employed. The results were further corrected for the nitrogen in the penicillin-sulfathiazole cream used, it being assumed, for purposes of calculation, that little or none of the sulfathiazole had been absorbed. (Absorbed sulfathiazole will have been excreted in the urine, so that the error introduced by this procedure in calculating the total balance is negligible, especially in view of the other sources of error. For accurate assessment of the exudate nitrogen some account would of course have to be taken of the exact amount of sulfathiazole remaining in the dressings.) Duplicate determinations on samples of the uniform mixture generally agreed to within 0.5–1 per cent.

Earlier estimations of exudate protein were made by Miss E. Semeonoff by soaking the dressings in water, treating a sample of the solution with sulphosalicylic acid and matching the resultant turbidity with the permanent standards of King and Haslewood.⁴

Food A fraction, usually one fifth, of the food was kept aside and at the end of the balance period ground to a uniform paste. A portion of this (e.g. 50–100 Gm.) was heated on a water bath with a little sulphuric acid for several hours, and samples of the resulting solution or fine suspension were taken for Kjeldahl analysis, the digestion mixture of Chibnall, Rees and Williams⁵ being used. In most of the balances eggs were not tested, on account of the food shortage, and the nitrogen was calculated from tables (McCance and Widdowson⁶) on the basis of the number and average weight of eggs consumed. All other nitrogenous foods were analysed.

* The Cellophane was washed in order to remove a water-soluble nitrogenous substance that might have contaminated the dressings. The washed film was dried and autoclaved before use.

** While every effort was made to avoid loss it is probable that in some cases there was a slight leakage of exudate.

Vomit was homogenised in the same way as food, and a portion taken for analysis

Plasma protein was estimated by the micro-digestion and nesslerisation method of King⁷ Checks on reagents, digestion and colorimetric matching were carried out at intervals by using pure solutions of glycine, when satisfactory results were obtained In some cases serum protein was estimated, with the phenol reagent of Folin and Ciocalteu (Greenberg, 1929⁸), in Mr Garfield Thomas's laboratory

Urinary creatinine and creatine were determined by Folin's⁹ method In a few cases a modified Benedict method for total creatinine, described by Macy,¹⁰ was tried it consists in evaporating the urine with normal hydrochloric acid, the drying being completed on a water bath to avoid charring and the lead treatment being omitted Macy states that this method was found satisfactory in her study of creatine excretion in children, but she investigated normal children, and in the present writer's experience the residue from the urine of burned patients sometimes darkens sufficiently on evaporation with hydrochloric acid to give a high result Creatinine and creatine estimations were usually done within 24 hours of receiving the urine

Plasma chloride was determined on 0.5 or 1 ml by digestion with silver nitrate in nitric acid and back titration with alcoholic potassium thiocyanate after the addition of alcohol Blood was collected under liquid paraffin and the plasma separated as soon as possible

Urine chloride was determined by the Volhard method, essentially as described by King⁷

Blood sugar was estimated by the method of Folin and Wu adapted for 0.1 ml, described by Harrison.¹¹

Calculation of the areas burned was done by the surgeon and was based on Berkow's¹² values

RESULTS

Urinary nitrogen excretion The urinary nitrogen excretion was measured in 20 cases, in 7 of which nitrogen balances were carried out Results in a number of other cases are omitted for the reason given above The cases are arranged in four arbitrary groups, as in the Glasgow Burns Unit report (L Colebrook *et al*, 1944¹³), viz

Group I	1-5 per cent of body surface burned
Group II	6-15 per cent of body surface burned
Group III	16-30 per cent of body surface burned
Group IV	over 30 per cent of body surface burned

The results are summarized in Table I, from which it will be seen that few of the urinary nitrogen figures in Groups I and II are excessive and that some are in fact low The highest nitrogen output observed was in Case 15, a man of 28 with 20 per cent burns, who excreted 40 Gm of nitrogen in a 27-hour collection of urine beginning three days after the burning This high loss

TABLE I—*Urinary Nitrogen Excretion in Burn Cases*

Case No	Age Sex	Burn		Daily Urinary Nitrogen	Plasma Transfused	Remarks	Lived or died (day)
		Total	Deep				
GROUP I CASES							
1	54 F	5%	0	Average 8.0 Gm N per day for first 8 days	None	Epileptic Admitted with slight infection of burns (quickly controlled)	L
2	25 M	2½%	1%	Average 10.1 Gm N per day for first 3 days	None	Afebrile Uninfected	L
3	37 M	2½%	1½%	Average 13.8 Gm N per day from 2nd to 5th day	None	Afebrile after 3rd day Uninfected	L
4	58 M	1%	1%	Average 14.5 Gm N per day for first 6 days	None	Afebrile after 3rd day Uninfected	L
5	13 M	4%	0	Average 7.2 Gm N per day from 2nd to 6th day	None	Febrile first week but uninfected	L
GROUP II CASES							
6	10 M	6%	0	Average 4.9 Gm N per day for first 13 days	None	Afebrile after 3rd day Uninfected	I
7	30 M	15%	5%	Average 15.6 Gm N per day for first 18 days (no urine collections on 9th 10th 11th 14th and 15th days)	1 litre	Slight pyrexia with low grade infection first 6 weeks	I
MI Urine (24 hrs) Gm N							
8	16 M	7%	3.5%	530 (2nd day)	None	Clinically uninfected throughout but slight pyrexia for first 7 days (See case notes below)	I
				2260			
				2730 +			
				2570			
				1685			
				2200			
				2020			
				1200			
				990			
				1280			
				990			
				1270			
				1000 +			
				1115			
				197			
9	29 M	6%	0	1900	None	Clinically uninfected throughout Afebrile after first 48 hours (See case notes below)	L
				1930			
				1860			
				1750			
				2550			
				1700			
				1400			
				1575			
				1560			
				1700			
				138			
10	9 M	6%	3%	Average 7.7 Gm N per day from 2nd to 7th day	None	Low grade infection with pyrexia 2nd week	I
MI Urine Gm N							
11	58 M	9%	4%	1070 (6 hrs)	None	Clinically uninfected and afebrile throughout (See case notes below)	I
				1300 (13 hrs)			
				2480 (23 hrs)			
				390 (1 hr)			
				1455 (24 hrs)			
				2595 (26 hrs)			
				1610 (22 hrs)			
				2595 (24 hrs)			
				470 (1½ hrs)			

METABOLIC STUDY OF BURN CASES

TABLE I—*Urinary Nitrogen Excretion in Burn Cases (Cont)*

Case No	Age, Sex	Burn		Daily Urinary Nitrogen	Plasma Transfused	Remarks	Lived or died (day)
		Total	Deep				
12	27 F	9%	7%	Ml Urine (24 hrs) Gm N			
			10 days after admission	1100 (17½ hrs)	5 55	None Clinically, slight low grade infection Temperature never above 100° F (See case notes below)	L
				1840	9 8		
				1880	9 2		
				1010	6 15		
				1400	7 35		
				1850	10 85		
				900 (6 hrs)	6 05		
				365 (18½ hrs)	3 15		
				830	13 35		
				1385	8 6		
				730	13 6		
				1160 (27 hrs)	8 5		
				1280	8 25		
				1135	3 4		
				1400	5 3		
				1950	7 1		
				2010	7 65		
				1150 (22 hrs)	4 85		
				1975	8 5		
				2060	7 35		
				1820 (25 hrs)	6 95		
13	58 F	15%	10%	Urine + exudate loss given in Table 2	2 2 litres		
GROUP III CASES							
14	7, F	30%	30%	Average ca 6 Gms N per day for first 9 days (but some specimens incomplete)	Nearly 2 litres	Burns uninfected but some pyrexia first few days	L
15	28 M	20%	15%	Average 19 3 Gm N per day for first 11 days (omitting 2 incomplete collections) and 15 7 Gms per day for next 14 days (omitting 2 incomplete collections) Highest output was 40 1 Gm in 27 hrs 3-4 days after burning	5 6 litres	Low grade infection and little fever first 2 weeks	L
16	23 F	22%	17%	Ml Urine (24 hrs) Gm N			
				680 (4 hrs)		5 8 litres Febrile first 8 days (See case notes below)	D (25)
				840 (16½ hrs)	3 25		
				1365	8 5		
				780	10 2		
				725	10 0		
				1505	13 2		
				2070	15 2		
				2105	17 4		
				2260	15 2		
				2310	17 0		
				2285	16 0		
				2610	18 45		

TABLE I—*Urinary Nitrogen Excretion in Burn Cases (Cont)*

Case No	Age, Sex	Burn		Daily Urinary Nitrogen	Plasma Transfused	Remarks	Lived or died (day)
		Total	Deep				
GROUP IV CASES							
17	21 F	72%	50%	Average 19.5 Gm N per day for first 11 days (? some specimens incomplete)	7.6 litres	Some fever throughout ? Chest infection	D (12)
18	14 F	73%	58%	Average 10.7 Gm N per day for first 7 days (omitting one incomplete collection) and 11.9 next 10 days. Then incontinent of urine	5.2 litres	Febrile throughout. Endocarditis and low grade infection of burns	D (90)
19	17 M	60%	25%	MI Urine (24 hrs) Gm N	22 litres (approx)	Febrile throughout. Pyocyanus infection	D (4½)
				520 (18 hrs) 3.3			
				1500+ 7.2+			
				1330 9.4			
				530 6.4			
20	4 F	50%	50%	See nitrogen balance notes below	2.9 litres	Febrile 5 weeks with low grade infection (See case notes below)	L

of nitrogen in the urine was not maintained, however, and his average daily excretion over a number of days, though above the normal amount, was not as high as might be expected. Case 19, a boy of 17 with 60 per cent burns, excreted small amounts of nitrogen in the urine during the four and a half days he lived. Some kidney damage was found at autopsy and this was confirmed by histological examination. This patient received methionine by mouth two days after admission, but it is impossible to say what effect it had. Case 18, a girl of 14 with 73 per cent burns, was given methionine at the suggestion of Professor R. A. Peters, but as by that time the patient was incontinent of urine any effect the methionine might have had on the urinary nitrogen excretion was not apparent.

Nitrogen balances. Table II gives details of 16 nitrogen balances carried out in 7 cases of burns ranging from 6 to 50 per cent of the body surface. Detailed case notes are given below, and these are followed by a discussion of the findings. Unfortunately, it was impracticable to weigh any of the patients (except Case 20, a small child) as the necessary apparatus was unobtainable at the time.

In Table II a distinction is made between the nitrogen taken in the food and that of intravenous plasma, and where possible between urine nitrogen and exudate nitrogen. In the experience of Major J. A. F. Stevenson,¹⁴ plasma given intravenously does not immediately increase the urine nitrogen, apparently being simply added to the pool of body protein (cf. Best and Taylor¹⁵). This means that in nitrogen balance experiments in burns there are two things to consider:

- (a) the total nitrogen balance over a period, including any plasma protein lost in the exudate and protein given intravenously,

TABLE II—Summary of Nitrogen Balances in Terms of Average Daily N Intake and Output Over Each Balance Period

Case No Sex Age, Extent and Time of Burn	Average Daily N Intake (Gm)			Average Daily N Loss (Gm)			Remarks
	Balance Period	By		Urine + Faeces Exudate	Total (Gm/Day)	Nitrogen Balance (Gm/Day)	
		Mouth	I V				
No 8 M, 16 7% (3.5% deep) 4 p m, 9/8/45	6 a m 10/8-10 a m 17/8 10 a m 17/8-10 a m 22/8 10 a m 29/8-M D 3/9	8 6 20 0 23 3	0 0 0	23 1+ 19 2 14 7+	23+ 19 2 14 7+	-14 5+ + 0 8 + 8 6 ca	Large quantities of exudate Slight exudation Serum protein 9/8/45 6 4 Gm/100 ml 18/8/45 5 6 Gm/100 ml
No 9, M, 29 6% (superficial) 11 30 p m, 4/9/45	M N 4-5/9-10 a m 10/9 10 a m 10/9-10 a m 15/9	24 6 24 7	0 0	18 5+ 17 8	18 9+ 17 8	+ 5 7- + 6 9 ca	Average calorie intake from 17-22/8/45, 2700 per diem, from 29/8-3/9/45 3270 per diem 5/9/45 Serum protein 5 9 Gm/100 ml 9/9/45 Serum protein 6 1 Gm/100 ml
No 11, M, 58 9% (4% deep) 10 30 a m 14/6/46	1 p m 14/6-9 30 a m 20/6	19 75	0	16 15	16 3±	+ 3 45 ca	Average calorie intake from 6-10/9/45 3900 P D from 11-14/9/45, 3800 P D 14/6/46 Plasma protein 6 4 Gm/100 ml 15/6/46 Plasma protein 6 1 Gm/100 ml 20/6/46 Plasma protein 6 1 Gm/100 ml
No 12, F, 27 9% (7% deep) 9 50 p m, 27/4/46	3 30 p m 7/5-3 p m 14/5 1 30 p m 15/5-11 a m 20/5 11 a m 20/5-11 a m 25/5 11 a m 4/6-10 a m 8/6	14 7 4 3 10 6 12 85	0 0 0 0	+ vomit } 10 3 } 10 75* } 7 25† } 7 70	10 8 11 75* 7 25+ 7 70	+ 3 9 - 7 45 ca + 3 35 ca + 5 15	1 day's urine (13/5-14/5) thrown away Probable N content allowed for Grafted between 1st and 2nd balances * Some vomit not kept † Figure includes menstrual blood
No 13, F, 58 15% (10% deep) 12 20 p m, 15/5/46	1 25 p m 15/5-3 p m 22/5	6 9	2 5	9 4	10 4+	- 1 0+	Plasma protein 24/5/46 5 4 Gm/100 ml Plasma protein 4/6/46 4 9 Gm/100 ml Plasma protein 13/6/46 5 7 Gm/100 ml (See Figure 1 for plasma protein levels)
No 16, F, 23 22% (17% deep) 10 30 a m, 15/3/46	3 30 p m 15/3-11 a m 21/3 11 a m 21/3-2 30 p m 26/3	8 25 18 7	7 95 0	16 2 18 7	14 8 20 45	+ 1 4 ca - 1 75	Until 17/3/46 patient had only sodium lactate by mouth Caloric intake from 17-21/3/46 averaged 1200 per diem Caloric intake for 2nd period averaged ca 1650 per diem from milk, eggs and glucose (not counting bread, meat and potatoes)
No 20 F, 4 50% (Deep) 9 30 a m, 27/6/46	6 p m 27/6-5 p m 4/7 5 p m 4/7-10 a m 11/7	2 9 7 8	3 3 0	6 2 7 8	8 05 6 6	- 1 85 + 1 2	See Figure 1 for plasma protein levels Approx Caloric Intake/Day 1st Period 2 " 1500 3 " 1350+ 4 " 1090+ 5 " " 6 " 1450+
	17/7-21/7 26/7-30/7 5/8-8/8 M D 19/8-3 p m 24/8	10 5+ 9 5 12 0± 16 4	0 0 0 0	10 5+ 9 5 12 0± 16 4	8 9±	+ 7 5 ca	47 lbs 45 lbs 47 lbs 39 lbs 42 lbs

- (b) the metabolic state of the patient on a particular day or over a period ("metabolic" nitrogen balance), in calculating which, according to Stevenson, intravenous plasma and protein lost in the exudate should probably not be included

GROUP II CASES

Case 8—B S, a boy of 16, received flash burns of the face and hands while at work on 9/8/45 and was admitted on the same day. His serum protein, as determined colorimetrically with the phenol reagent, was 6.4 Gm per 100 ml on admission. A nitrogen balance was started next morning and carried on until the dressings were changed a week later, when a new balance was commenced. Unfortunately a satisfactory technique for the estimation of the nitrogen lost into the dressings had not at the time been evolved by us, and the negative balance was certainly larger than the figure given in the table (as indicated by the plus sign). Over the second balance period, which consisted of five days, the patient was more or less in nitrogen equilibrium (neglecting some slight exudation during this period), although nine days after admission his serum protein, determined as above, had fallen to 5.6 Gm per 100 ml, and in the third period he was in marked positive balance. The urinary nitrogen losses were somewhat above normal levels but the large negative nitrogen balance in the first period was evidently due chiefly to the small amount of food eaten during the first few days.

The patient was clinically uninfected throughout but had slight pyrexia for the first seven days. Bacteriology chiefly Gram-negative cocci after the first three days, later staphylococci.

Case 9—W P, a man age 29, received blister burning of the right ankle joint and knee on 4/9/45 through coming into contact with boiling water. A nitrogen balance was commenced on admission at midnight, but unfortunately some urine was discarded by the night staff. However, the quantity lost is believed not to have been large, and urine collection was resumed at about 10 A.M. on the following morning. One breakfast was not sampled in the absence of the metabolic nurse and the approximate nitrogen content was calculated with the aid of tables. Serum protein, measured with the phenol reagent, was 5.9 Gm per 100 ml on 5/9/45 and 6.1 on 9/9/45, i.e., towards the end of the first balance period, during which the patient was well in positive nitrogen balance. A second balance experiment over the next five days showed him to be again in positive nitrogen balance. By 21/9/45 the patient was practically healed, and he was discharged on the 24th.

The patient was clinically uninfected throughout, and afebrile after the first 48 hours. Bacteriology of burned area sterile for first 6 days, then a few micrococci.

Case 11—J B, a man of 58, burned his right hand and arm and right knee when he fell over a pot of molten metal on 14/6/46. A nitrogen balance was started soon after admission. The plasma protein was 6.4 Gm per 100 ml 4½ hours after burning and 6.1 on the next day. It was still 6.1 at the end of the balance period, over which the patient was in positive nitrogen balance. No more balance experiments were done in this case.

The patient was clinically uninfected and afebrile throughout, and healed in four weeks. Bacteriology of burned area sterile for first six days, then diphtheroid bacilli and non-haemolytic streptococci (on one occasion only).

Case 12—P G, a woman of 27, an epileptic, had a fit on 27/4/46 and fell onto the fire. The patient was treated at another hospital before being transferred to this hospital on the following day. Nitrogen balances were started on 7/5/46. Skin grafting operations were carried out on the 16th. The adverse effect on nitrogen balance was due

to a general reduction in food intake, not to any significant increase in urine nitrogen. It should be noted that the figures given in Table 2 take no account of blood lost during grafting operations between balances. Subsequently it was not difficult to get the patient into positive nitrogen balance, though plasma proteins remained low for a time. Urinary nitrogen excretion also remained at a low level (see Table I).

Clinically there was a slight low grade infection by micrococci, non-haemolytic streptococci, coliform bacilli and staphylococci. The temperature was never above 100°F.

Case 13—A R, a woman of 58, also an epileptic, had a fit and fell onto the fire on 15/5/46. Plasma protein soon after admission was 6.9 and fell rapidly to 5.5 Gm per 100 ml 8½ hours later (Fig. 1). A nitrogen balance was started on admission and continued until the dressings were changed on 22/5/46. Owing to incontinence an uncertain amount of the urine was lost and some also leaked into the dressings together with a little feces, so that it is impossible to give an accurate figure for the nitrogen loss or to distinguish between urine and exudate nitrogen. It will be seen that the patient was in negative balance, though the urinary nitrogen averaged only about 8 Gm per day. Plasma transfusions accounted for nearly 28 per cent of the total nitrogen intake during this period. Further balances were not attempted as the problem of collecting urine became too difficult. During changing of the dressings on 22/5/46 the patient collapsed with respiratory distress. Then the pulse, temperature and respiration rose and her condition remained critical. On 29/5/46 the plasma CO₂-combining power was found to be 40 volumes per cent and the plasma pH 7.30 (Mr. Garfield Thomas). Saline containing sodium bicarbonate and glucose was administered by Ryle's tube, but the patient died on the same day (29/5/46), probably as the result of a pulmonary embolism. A few days before death she developed a sudden transient right-sided hemiplegia.

The burned areas were clinically uninfected but there was low grade infection for the 14 days she survived. Bacteriology: staphylococci and Gram-negative cocci.

GROUP III CASE

Case 16—J R, a woman of 23, was subject to "dizzy spells" that had been diagnosed as epilepsy at some previous time. During one of these fits, on 15/3/46, she fell onto the fire and received burns mainly over the right side of the body—neck, pectoral region, scapular region, hip, buttock, arm and hand. A nitrogen balance was started soon after the burns had been dressed, and carried on until the next dressing, which was on 21/3/46, when a new balance was begun. It will be seen from the table that the patient was in negative metabolic balance over the first period but in slight positive total nitrogen balance when the transfusions and exudate loss are taken into account. The total nitrogen in the plasma transfused was slightly more than that lost in the exudate over both balance periods. The patient then became incontinent of urine and no further balances were done. Plasma protein values are given in Figure 1. After a skin grafting operation on 2/4/46 the patient had an epileptiform attack which was repeated every few minutes. These fits became less frequent by 7/4/46, but on the 8th they recurred and she suddenly collapsed, became cyanosed and died. A specimen of cerebrospinal fluid obtained by lumbar puncture immediately after death was found to be quite clear and to contain

Sugar	97 mgm per 100 ml (Folin-Wu)
Protein	5 mgm per 100 ml (turbidimetric with sulphosalicylic acid)
Chloride (NaCl)	777 mgm per 100 ml
Urea	47 mgm per 100 ml
Globulin	no reaction (ammonium sulphate ring test)

The patient was febrile for the first eight days (low grade infection by proteus, pyocyanus and staphylococci).

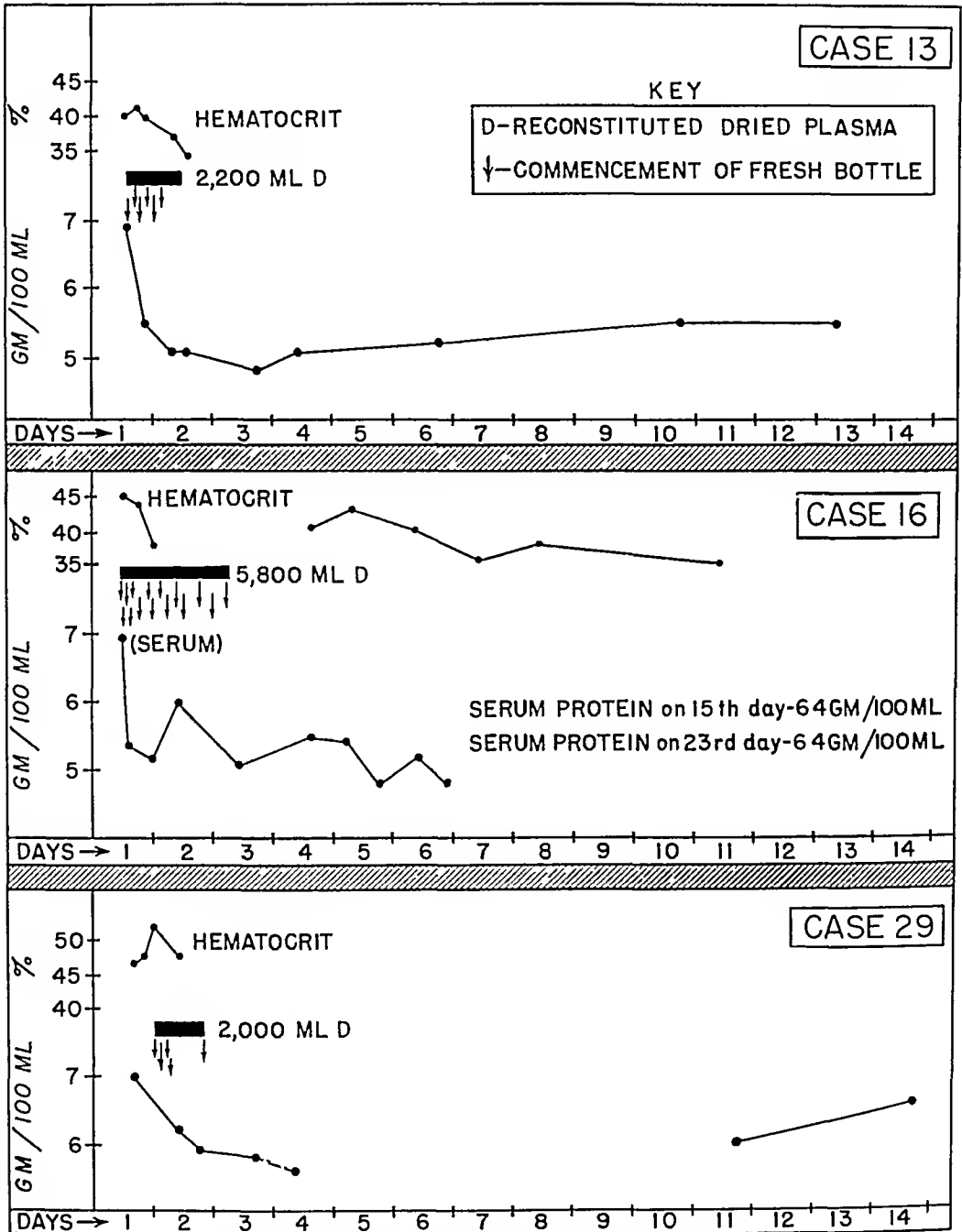


FIG 1—Plasma protein levels in three burn cases

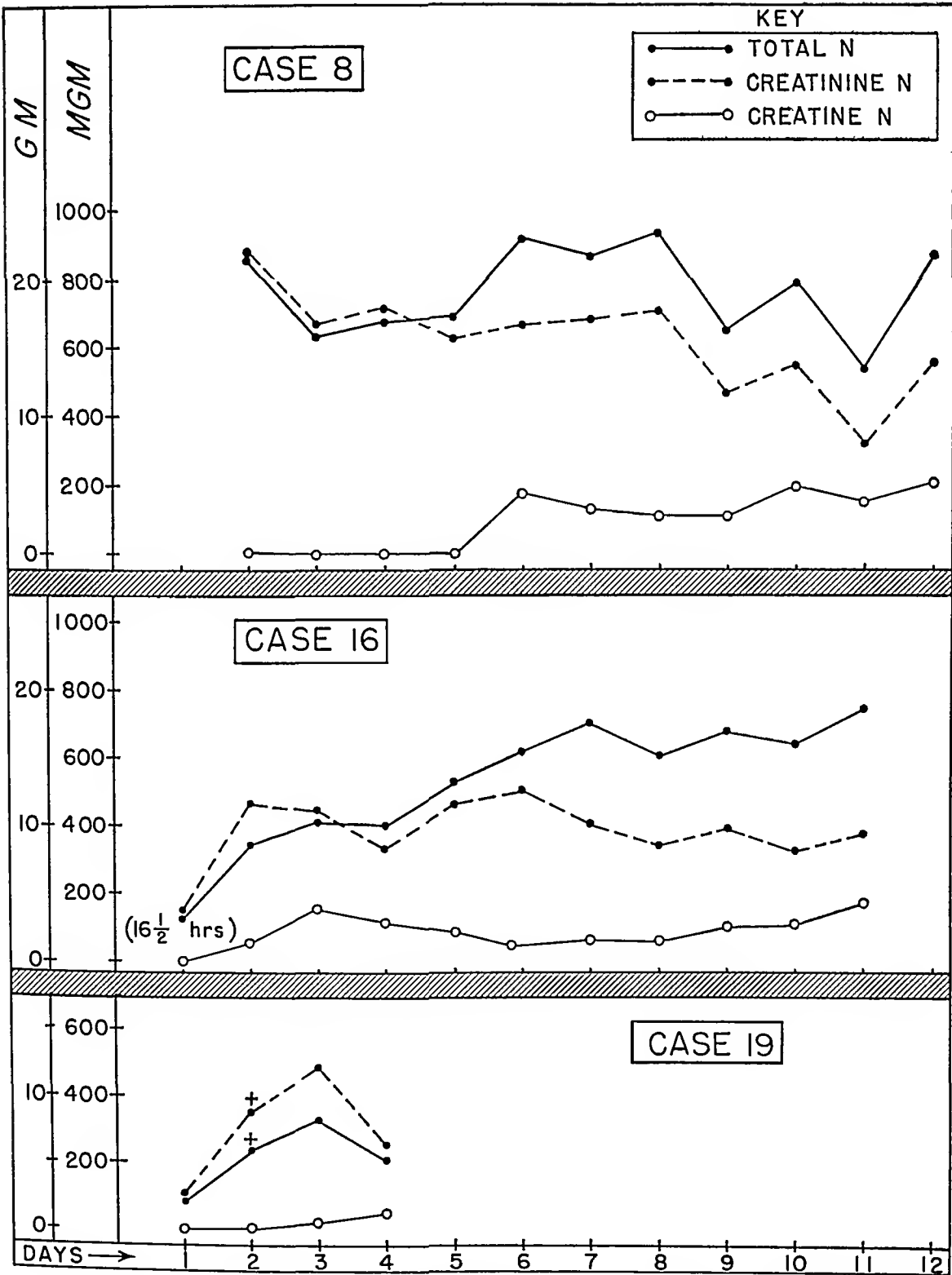


FIG 2—Urinary total nitrogen, creatinine N and creatine N excretion in three burn cases

GROUP IV CASE

Case 20—P McN, a girl of 4, received severe burns at 9 30 A M on 27/6/46 when her small brother threw a lighted match at her, igniting her clothes. The burned area was estimated at 50 per cent (deep) and extended over trunk and arms. A nitrogen balance was started on admission and carried on until the dressings were changed 7 days later. After the third day the patient became incontinent of urine during the night, but it was found possible to collect the urine in Cellucotton. Unfortunately it was not possible to differentiate between urine and exudate nitrogen as the dressings became contaminated with urine and vomit. The patient was in negative balance over the first seven days and in slight positive balance over the second week. Third and fourth balances were commenced but the output could not be assessed on account of (a) complications arising from the necessity for only partially changing the dressings at different times, and (b) failure of the night staff to collect urine. However, a record was kept of the intake. A sixth balance was commenced on 19/8/46, by which time the patient was well on the way to recovery and in positive nitrogen balance. Skin grafting was done between the end of the second and beginning of the sixth balance periods. Owing to the extent of the burns it was not possible to do much blood analysis, but plasma proteins were estimated at intervals and were as follows:

29/6/46	6.2 Gm per 100 ml
3/7/46	5.9 Gm per 100 ml
8/7/46	6.0 Gm per 100 ml
22/7/46	6.0 Gm per 100 ml
27/7/46	6.2 Gm per 100 ml
6/8/46	6.2 Gm per 100 ml
16/8/46	5.8 Gm per 100 ml
23/8/46	6.2 Gm per 100 ml
6/9/46	6.8 Gm per 100 ml

Records of the child's weight were kept and are given in the table. The loss of weight between the 25th July and 8th August followed a period of prolonged pyrexia—she was febrile for five weeks, with a low grade infection by staphylococci and Gram-negative cocci (later some coliforms).

Hemoglobin values (Haldane method) in this case were as follows:

3/7/46	52 per cent
8/7/46	74 per cent
17/7/46	64 per cent
24/7/46	87 per cent
27/7/46	57 per cent
8/8/46	66 per cent
10/8/46	94 per cent
16/8/46	86 per cent
23/8/46	84 per cent
29/8/46	90 per cent

Loss of blood during skin grafting procedures, and transfusion of packed cells, occurred between balance periods and are not included in Table II.

DISCUSSION

It appears that negative nitrogen balances in our cases were due to low intake rather than to a high output of nitrogen, and that when it was possible to get patients eating well it was not very difficult to get them into nitrogen

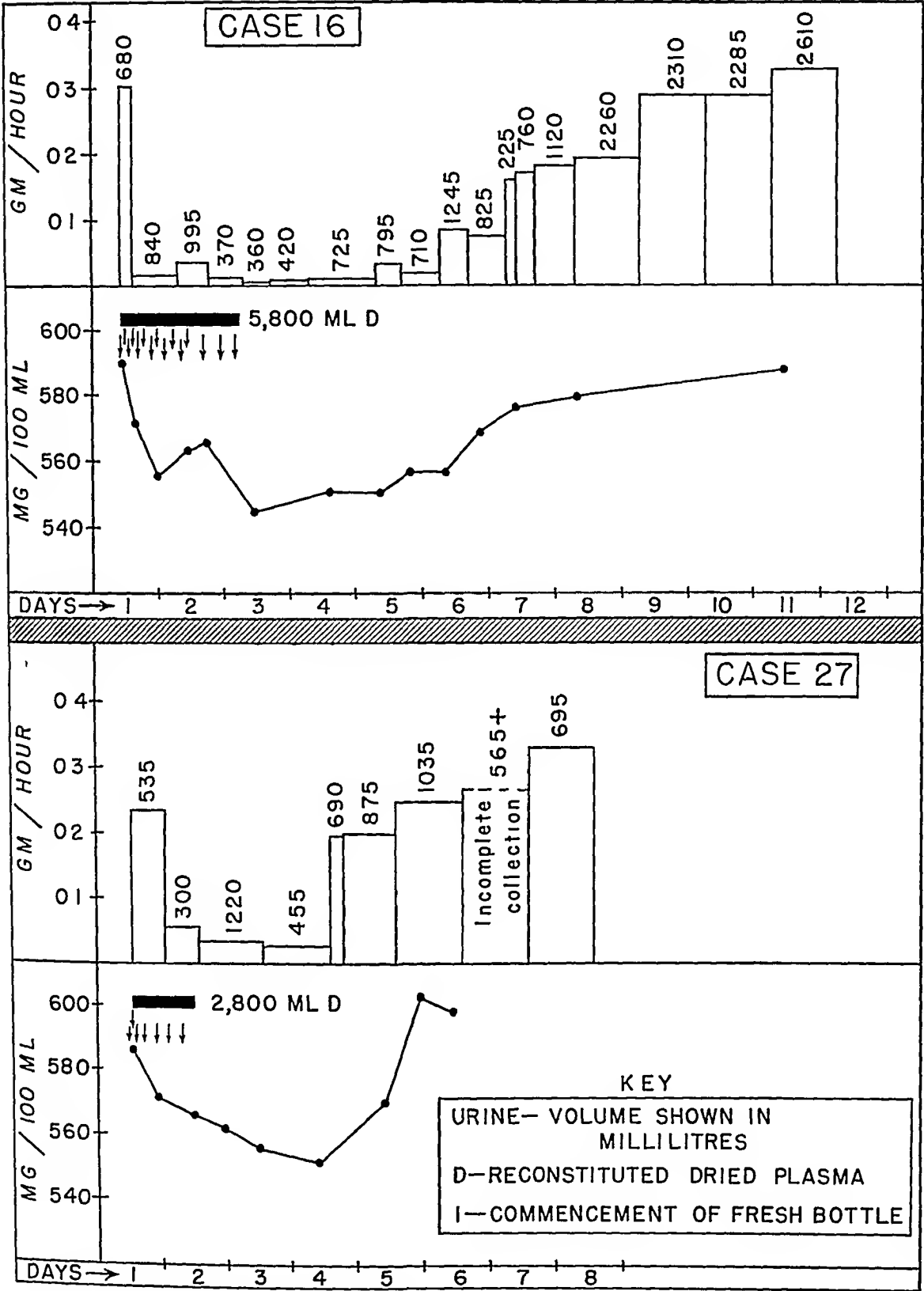


FIG 3—Urinary chloride excretion and plasma chloride levels

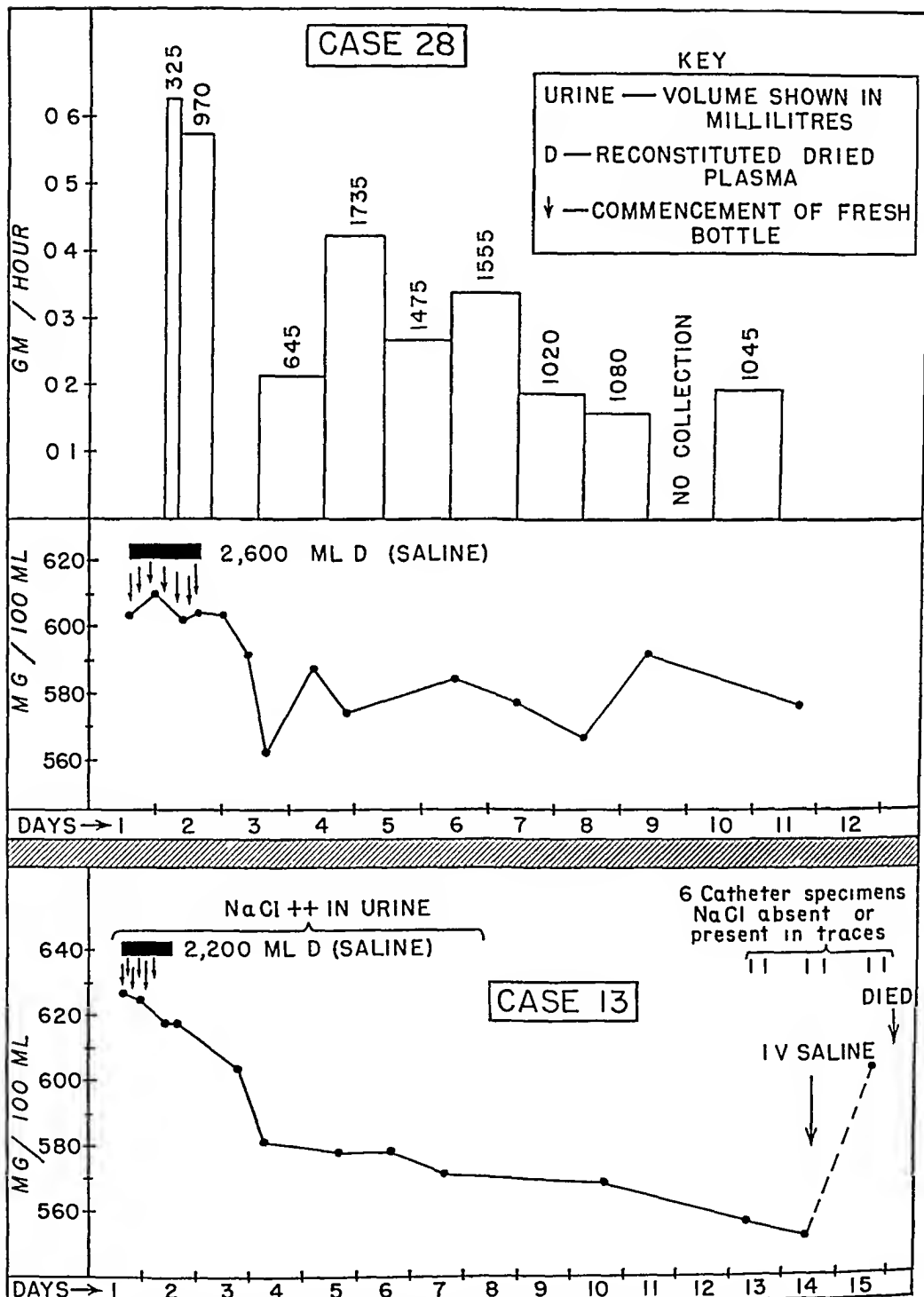


FIG 4—Urinary chloride excretion and plasma chloride levels

equilibrium Taylor *et al*¹⁶ and Co Tui *et al*¹⁷ have shown that there is a marked tendency for burned patients to get into negative nitrogen balance, and Co Tui has drawn attention to five possible sources of nitrogen loss (1) intratissue loss into the burned areas, (2) loss in the exudate, (3) hemoglobinuria, (4) reduction in caloric and nitrogen intake as a result of anorexia, (5) the possible loss due to an "antianabolic period," probably as a result of altered hormonal balance. While it must be admitted that the loss in the exudate can be very large, we would draw attention to the fact that this loss, as well as the intratissue loss referred to in (1) above, is largely compensated (so far as total nitrogen balance is concerned) by the plasma transfusions. Proteinuria was encountered in most and hemoglobinuria in some of our severely burned patients, but the total amount of protein lost in this way was not large. With regard to the fifth source of loss, we have usually found the urinary nitrogen to be not markedly above the normal, and in fact some of our cases, especially women, excreted subnormal amounts of nitrogen in the urine. Our findings are in agreement with the statement of Cope *et al*¹⁸ that extensive deep burns are not necessarily accompanied by a large loss of nitrogen in the urine. Cope *et al* attributed negative nitrogen balances in their cases to low caloric and nitrogen intakes, and the low excretion of nitrogen to the relative absence of infection. Most of our cases were relatively free from infection.

It seems likely that the nutritional state of the patient is at least as important as the extent of the injury in determining the level of nitrogen excretion, and it is possible that this may explain, to some extent, why we have not been able to confirm in all cases the large increases in urinary nitrogen output found by some of the American workers. Stevenson¹⁹ refers to patients, previously in a poor nutritional state, who showed very little negative nitrogen balance after an injury, and Munro and Chalmeris²⁰ have shown that the diet of the pre-fracture period has an important effect in modifying the metabolic response of rats to bone fracture.

Note on the food. Eggs and milk were used extensively and together contributed the greater part of the nitrogen and caloric intake of most of our balance cases. For example, in Case 20 (P. McN.) eggs accounted for from 22 to 36 per cent of the total nitrogen in each balance period, and milk 47 to 65 per cent. Casein hydrolysate was given orally in Case 12 (P. G.) but was poorly tolerated. It is doubtful whether hydrolysates are indicated except when digestion or absorption is impaired or when it is impossible to ingest sufficient protein in a more palatable form.

Supplements of glucose were given. Wherever possible the approximate caloric intake (calculated with the aid of tables) is shown in Table II.

It may be that protein and essential amino acids considerably in excess of the amounts adequate for maintenance of nitrogen balance are required for healing, but we have no exact data bearing on this.

NITROGEN IN THE EXUDATE FROM THE BURNED AREA

The nitrogen in the exudate was measured in seven other cases, in which

complete balances were not carried out, and the results are included in Table III together with those for Cases 9, 12 and 16. Wherever possible the urinary nitrogen is shown for comparison. The practice of measuring the amount of protein lost in each 24- or 48-hour period (see lower part of table) was discontinued on account of the possible risk of infection involved in frequent changing of the dressings.

Pressure dressings to minimize loss of exudate from the burned area were used by Cope and Rhinelander²¹ and by Koch²² in America, and investigated experimentally by Cameron *et al*²³ in this country. * Mr J McK Duncan of

TABLE III—*Nitrogen in the Exudate from the Burned Area*

Case No	Age Sex	Burn	Period	Exudate N (Gm)	Urine N (Gm)	Exudate N as % of total (excluding feces)
21 (S G)	37 F	5% (superficial)	First 7 days Next 7 days	2.1 0.45		
22 (J B)	7, M	5% (superficial)	First 5 days Next 5 days	1.75 0.5	33.6+ 53.7+	
9 (W P)	29 M	6% (superficial)	First 5 days	2.0	90.3+	ca 2%
12 (P G)	27, F	9% (7% deep)	First 7 days Next 5 days	3.5 5.0	55.0 47.2	6% 9.6%
23 (L H)	27, F	15% (8% deep)	First 7 days	11.7	30.2+	
16 (J R)	23, F	22% (17% deep)	First 6 days Next 5 days	20.2 15.3	60.4 84.1	25.0 15.4
2 (G J)	25, M	2½% (1% deep)	First 24 hrs Next 24 hrs Next 24 hrs	0.29* 0.16* 0.09*	30.2	1.8
24 (A J)	31, F	4% (1% deep)	First 1½ days Next 48 hrs	1.20* 1.68*		
25 (H D A)	52, F	7% (superficial)	First 24 hrs Next 24 hrs Next 24 hrs	1.38* 1.92* 1.47*		
26 (J M)	9 F	8% (3% deep)	First 24 hrs Next 24 hrs Next 48 hrs	0.67* 0.55* 0.96*	29.2	7.0

The above values for exudate N are calculated as described under 'Methods' and are therefore likely to be slightly low (depending on how much of the sulfathiazole was absorbed).

* Protein determined turbidimetrically +6.25

this Unit has used pressure dressings in an attempt to control exudation, but we have no data demonstrating their effectiveness.

A quantity of blister fluid from a female, H B, with blister burns of

* Britain

the right hand and forearm was analysed and the results were as follows

Total nitrogen	0.56 Gm per 100 ml
Total protein	3.4 Gm per 100 ml
Albumin/globulin	1.6
Chloride (NaCl)	490 mg per 100 ml

It should be noted that as the clot of fibrin had already separated, the figure for total protein will be slightly low and that for the albumin/globulin ratio slightly high. Total protein and albumin were estimated by King's⁷ nesslerisation method for plasma, in which the separation of albumin and globulin is effected with sodium sulphite (Campbell and Hanna²⁴).

In a second case, W. H., a male aged 54, blister fluid (after separation of fibrin) was found to contain 5.1 Gm of protein per 100 ml, the albumin/globulin ratio being 3.3. The plasma protein in this case was 6.7 Gm per 100 ml and the plasma albumin/globulin ratio 1.9.

PLASMA PROTEINS

In two of the balance cases (Nos. 13 and 16) serial plasma protein determinations over several days were made and are shown in Figure 1. A less steep fall in the plasma proteins was found in Case 29 (Fig. 1); this man of 58 had burns involving the face, right arm and shoulder, left forearm and hands, and was not transfused. It is possible that the steep fall in plasma proteins was partly due to dilution with the transfused reconstituted plasma, which contains only five grams of protein per 100 ml. In other burn cases low values were found.

CREATININE AND CREATINE EXCRETION

The urinary excretion of creatinine and creatine as compared with total nitrogen is shown graphically in Cases 8, 16 and 19 (Fig. 2). Results in 15 other cases are not shown, for reasons already given, but it can be stated that the high output of nitrogen on the third to fourth day (27 hours) in Case 15 (20 per cent burn) was associated with a high output of creatinine (2.75 Gm) and creatine (1.55 Gm). Creatine was found in the urine of two other adult males, L. H. and B. S. (Case 8), with 15 per cent and 7 per cent burns, respectively, but was absent or present only in small amounts in that of four other adult males with burns of not more than 2½ per cent. In some cases of creatinuria, in females as well as in males, there appeared to be a peak at the second to the fourth day, but this may have been fortuitous. In Case 19 (60 per cent burn), in which the low excretion of nitrogen has already been remarked on, very little creatine was passed in the urine.

Creatinuria has been reported as occurring in normal healthy males (Hobson²⁵), but other workers, in extended studies, have failed to confirm this (cf. Tierney and Peters²⁶). In certain of our cases it would seem likely that the creatinuria was to some extent a result of the injury and associated

pyrexia Clark *et al*²⁷ and Croft and Peters²⁸ found that after a severe burn rats showed a sharp rise in creatine excretion Cuthbertson *et al*²⁹ in experiments on rats showed that fracture of the femur caused a definite loss of creatine in the urine that paralleled the curve of nitrogen excretion, although preformed creatinine remained relatively constant, and Cuthbertson³⁰ reported similar findings in a study of human fractures

It has been shown that the ingestion of readily assimilable carbohydrate is associated with creatinuria (Haldi and Bachmann,¹ Hobson²⁷) Our burn patients received quantities of a sodium lactate-fruit juice mixture by mouth, and in view of the intimate connection of lactic acid with carbohydrate metabolism the possibility that the creatinuria may have been due partly to the lactate-fruit juice mixture cannot be excluded

TABLE IV—*Proteinuria in Burn Cases*

Group	Total Number of Cases	Protein Free	Traces of Protein Only	Protein
I	18	7	*9	2
II	17	3	†10	4
III	8	0	3	5
IV	6	0	1	5
Totals	49	10	23	16

* 5 of these cases showed proteinuria for the first day only One case showed it on the 3rd day only

† 2 of these cases showed proteinuria for the first day only 2 cases showed no proteinuria on the first day and two others none on the first two days

PROTEINURIA

"Twenty-four-hour" collections of urine in 49 cases were tested for protein (sulphosalicylic acid test) for the first few days or longer The results (Table IV) are in agreement with those found in the Glasgow Burns Unit (Anderson and Semeonoff¹²) thus only two* out of 18 cases in Group I had more than traces of protein in the urine, whereas five of the six Group IV cases had protein present in more than traces Casts and blood cells were often found in the urine of these severely burned patients A strongly positive reaction for protein was given in Case 20, a girl of four with 50 per cent burns, by a 14-hour collection starting from eight hours after the burn The centrifuged deposit from the urine was found to contain a few granular casts and pus cells, but the urinary protein decreased to a mere trace within about four days This patient made a good recovery, in spite of the extensive burns

In two cases the urinary protein was estimated by Miss E Semeonoff by the turbidimetric method using sulphosalicylic acid and the permanent turbidity standards of King and Haslewood⁴ One of these, a girl of 14 with 73 per cent burns (Case 18), excreted on an average 0.24 Gm of protein per

* One of these two cases had an exceptionally large amount of protein in the urine, although the burn was only a light one (less than 1 per cent) There was almost certainly another cause for the proteinuria in this case

diem over the first ten days, and the other, a woman of 21 with 72 per cent burns (Case 17), excreted an average of 0.66 Gm per diem also in the first ten days

CHLORIDE EXCRETION AND PLASMA CHLORIDE LEVEL

A marked decrease in the urine chloride, amounting in some cases to almost complete suppression of chloride excretion, appears to have been of general occurrence in the moderate and severe cases, the output returning to normal in the course usually of a few days. A decrease in urine and plasma chlorides in burns was observed by Davidson in 1926³³ and by other workers, though not all have confirmed the lowering of plasma chloride (see Harkins³⁴). Figures 3 and 4 correlate chloride excretion with plasma chloride in four cases. Observations in Cases 16, 27 and 28, together with others in which a less complete picture was obtained, are in agreement with Davidson's suggestion that the lowered chloride excretion in burns is due not primarily to kidney change but rather to a lowering of the plasma chloride to below the renal threshold level (normally 562 mgm. NaCl per 100 ml plasma). This does not preclude the possibility of kidney damage being responsible in some cases—compare Cases 13 and 29 (below). In Case 13 intravenous saline was given from 12.30 P.M. on 28/5/46 and the plasma chloride was 604 mg per 100 ml at 3.30 P.M. on 29/5/46, yet a specimen of urine obtained by catheterization at 6 P.M. on 29/5/46 contained hardly any chloride. It appears that excretion of urine had almost ceased, and *post mortem* the bladder was found to be congested and to contain a very small volume of purulent fluid.

It is worth noting that reconstituted plasma,* prepared from citrated blood, is low in chloride content when made up with distilled water (A sample analyzed was found to contain 395 mgm per 100 ml). In view of the findings of Rosenthal,³⁵ Fox³⁶ and others, it was considered preferable to reconstitute the dried plasma with saline. In several cases normal saline was used by the surgeon, and this appeared to have the effect of delaying, if not entirely preventing, the fall in plasma chloride. It might possibly be better to use 0.2 per cent saline: this would bring the sodium chloride content of the reconstituted plasma to within the normal physiological range.

Cases 13, 20, 28 and 29 received plasma reconstituted with normal saline. In Case 20 chloride excretion in the urine was not diminished, as judged by qualitative tests, but on account of the extent of the burns the plasma chloride changes could not be followed. In the last of these cases (male, age 58, with 16 per cent burns), sodium chloride excretion was somewhat low, averaging 3.4 Gm per diem during the first four days, although the plasma chloride appeared to be normal most of this time (cf. McIver³⁷). Sodium chloride excretion rose to normal by the 24th day, but further observations of plasma chloride could not be made owing to the development of thrombosis.

* Birmingham, England

In severe burns the amounts of reconstituted plasma given intravenously are often very large, sometimes amounting to several times the blood plasma volume Mr Garfield Thomas has suggested that the presence of citrate and (if the plasma has been reconstituted with distilled water) the deficiency in chloride might affect certain of the liver function tests by altering the balance of electrolytes—a point to bear in mind when interpreting the results of these tests

TABLE V—*Blood Sugar after Burning*

Case No	Age and Sex	Burn	Time of Burn	Time of Blood Sugar Level	Remarks	Blood Sugar (mg %)
30	74 I	10% (8% deep)	2 45 a m	4 30 or 6 30 a m (?)	Lactate No previous history of diabetes ascertainable	298
31	15 F	15% (10% deep)	7 30 a m 7/12/45	10 30 a m 7/12 4 30 p m 7/12 10 0 p m 7/12 10 0 a m 8/12 10 0 p m 8/12 2 30 p m 9/12 10 0 p m 9/12	Lactate	137 162 112 105 127 125 138
32*	73 F	25% (10% deep)	3 30 p m 1/11/45	10 0 a m 2/11 2 15 p m 2/11 10 10 a m 3/11	Lactate Died 6 35 p m 3/11/45	290 355 290
15	28 M	20% (15% deep)	13/4/45 Admitted 12 30 p m	3 30 p m 13/4 9 30 a m 14/4	Lactate	123 161
3	37 M	2½% (1½% deep)	3 p m 28/12/45	6 0 p m 28/12 10 0 p m 28/12 12 45 p m 29/12 10 45 p m 2/12 8 0 p m 30/12	Lactate	106 106 137 130 118
22	7 M	5%	1 15 p m 18/2	4 0 p m 18/2 12 mdnt 18-19 9 30 a m 19/2	Lactate	139 95 100
33	25 F	40% (32% deep)	9 45 a m 21/1/46	a m 21/1		111
23	27 F	15% (8% deep)	5 30 p m 17/1/46	6 30 p m 17/1 10 30 p m 17/1 9 30 a m 19/1	No lactate till 8 15 p m	152 118 133
34	5 F	10% (2% deep)	12 45 p m 31/12/45	4 0 p m 31/12 6 0 p m 4/1	Lactate	128 103
16	23 F	22% (17% deep)	10 30 a m 15/3	11 30 a m 15/3 4 30 p m 15/3	Lactate from 12 midday	156 128
35	30 M	3%	8 30 a m 15/3	10 0 a m 15/3		110

* This patient received treatment with insulin Whether she had diabetes before burning is not known A catheter specimen of urine obtained at 12 30 p m on 3/11/45 showed

Sugar ++, Acetone +, Protein +, Chloride trace

BLOOD SUGAR

This was determined on venous whole blood or plasma (obtained for other estimations), by the method of Folin and Wu adapted for 0.1 ml Findings are given in the table In only two cases was a definitely abnormal value found, but as venous blood was used, the capillary blood sugar in a few of the others would possibly have been slightly above normal These patients were given quantities of a sodium lactate mixture to drink, as recommended

by Fox (1944)³⁶, but how far this, or the fruit juice in which it was made up, tended to raise the blood sugar is not known

SUMMARY

1. The daily urinary nitrogen excretion in 20 burn cases has been measured. In only a few was there an average daily nitrogen excretion markedly greater than normal, and in many patients it was somewhat low

2. Sixteen nitrogen balances in 7 cases have been carried out and the findings are discussed. In five of these cases the nitrogen in the exudate from the burned area was measured. The well marked tendency for burned patients to go into negative nitrogen balance is confirmed, but negative balances in our cases seemed to be due to low intake rather than to increased loss of nitrogen

3. Exudate nitrogen, measured in 10 cases, made up from 2 to 25 per cent of the total nitrogen output (excluding faeces)

4. A marked fall in plasma protein was observed soon after burning in three cases in which serial determinations were made over several days. Low plasma protein values were encountered in other cases also

5. Creatinuria was observed in three adult males with burns of 7 per cent, 15 per cent and 20 per cent of the body surface

6. Proteinuria was observed in many cases, especially in those with the more extensive burns

7. Plasma chloride was determined at intervals in a number of cases and correlated with urine chloride. The fall in plasma chloride noted by some earlier investigators was confirmed and is discussed in relation to intravenous plasma therapy

8. Blood sugar levels (venous blood, Folin-Wu method) after burns of various degrees of severity were measured in 11 cases. In two cases there was an undoubted hyperglycemia, and in a few others values were perhaps slightly high

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THE SURGICAL TRIANGLES OF THE INGUINOPECTINEAL REGION (INGUINA) THEIR CLASSIFICATION, PARIETAL RELATIONSHIP AND SIGNIFICANCE IN HERNIA REPAIR

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FROM THE SURGICAL SERVICE OF THE VETERANS ADMINISTRATION

A CONCEPT HAS NOT BEEN PREVIOUSLY PROPOSED, in so far as we have been able to ascertain, which considers the inguinal region as a series of closely interrelated triangles approaching a composite pyramid

Contributing to the existing confusion and consequent lack of accurate comparative criteria for surgical procedures in this area are lack of an accepted classification of the surgical triangles of the inguinopectineal region, inaccuracy of anatomic description, variations and distortions of anatomic structures, failure to evaluate properly factors concerned in the development of hernia, faulty terminology and lack of a logical system of nomenclature

Triangulation of the hernia-bearing region of the lower abdomen began in 1806 when Hesselbach¹ published a treatise on the origin of inguinal ruptures. He described the triangle medial to the inferior epigastric vessels with the sheath of the rectus and inguinal ligament forming its sides. Moreover, he made the original observation that it is the most vulnerable portion of the inguinal canal. The triangular concept of Hesselbach seemed to wane until Ferguson² (1895) recognized the frequent existence of a definite weakness in the medial angle of the canal. Since that time perpetual controversy has been going on over the minor ligaments and varying condensations of the fascia transversalis in or adjacent to this vulnerable triangle. These ill-defined fascial bands, such as Hesselbach's or interfoveolar ligament, internal crus of the internal ring (Browne³), Henle's ligament, the iliopectic tract, the ligamentum inguinale reflexum (Colle's fascia) and the femoral ligament are, for all practical purposes, anatomic frills. Since these fascial structures are inconstant and rarely of clinical significance in offering any structural support in reparative maneuvers, it would seem preferable to place less emphasis on them as definitive ligamentous or fascial entities.

An important clinical feature of the inguinopectineal region is its predilection to the formation of hernia. Contributing to this weakness are several predisposing factors. (1) the presence of so many orifices in the parietes which are essential for the passage of various anatomic structures. Although they are provided with fortifying fibers architecturally arranged for greater security, there inevitably exists a potential weakness at these points of vascular, visceral or urogenital exit. (2) Because of its dependency and the

concentric narrowing of the lower abdomen, the intra-abdominal pressure is increased in this region (3) And most important of all, the anomalies which occur in the development of the undifferentiated abdominal wall plate concomitant with the descent of the testis. These various generic factors, anatomic, embryologic and dynamic, frequently coexist and collaborate in the evolutionary process of herniation.

The whole hernia-producing region of the lower ventral abdominal wall is referred to collectively as the inguina. It is pyramidal in outline and on viewing it anteriorly and from within outward, it has depth or a third dimension. Such an observational view directs attention to the incipient development of hernia at its initial exit or fovea on the serous side of the abdominal wall. In contrast, it is difficult to reconstruct the retrogressive course of the hernial protrusion in the presence of a full-blown hernia after there has occurred structural distortion and parietal evagination. Early operations for the radical cure of hernia were focused exclusively on maneuvers for the eradication of the large saccular anomaly without giving adequate consideration to the role of the adjacent parietal structures. Lack of correlation and utilization of the parietal strata in the early reparative procedures resulted in anatomically imbalanced operations which temporarily delayed surgical progress in herniology. This technical gap is recognizable and is reflected in the evolution of some of the modern operative procedures.

Realizing the existing confusion and need for anatomic research in the inguinohypogastric region, Anson⁴ and his associates, McVay,⁵ Morgan⁶ and Ashley⁷ have made painstaking dissections of this region but confined their investigations chiefly to the transition of the musculofascial planes and the correlation of congenital and acquired anomalies. Much of our modern anatomic knowledge of this region stems from this study, unfortunately, however, the fascial and ligamentous boundaries of the controversial triangles were only casually mentioned by them. The need for integration of the surgical triangles and a better understanding of their relationship and variability to the hernial protrusion still exists. We should therefore like to present an anatomic outline of the triangles of the inguinopectineal region (inguina) that is applicable to the whole vulnerable or hernia-producing region. It is self-evident that if the surgeon is fully acquainted with the composite anatomy and the evolutionary development of hernia, he should be better able to recognize and adequately to correct the faulty saccular or parietal weakness which predisposes to the formation of the hernia.

CLASSIFICATION OF THE SURGICAL TRIANGLES

Any given triangle should have a specific and unvarying anatomic boundary. Temporary alteration in size with co-existing distortion of its boundary by a herniated mass should not change the basic anatomic unit.

The classical anatomic arrangement as presented by the modern textbooks of anatomy and surgery is that of two distinct but, for the most part, unrelated inguinal and femoral regions. The region superior to the inguinal

ligament is known as the inguinal region and is the region intimately related to the development and repair of inguinal hernia. The region lying inferiorly

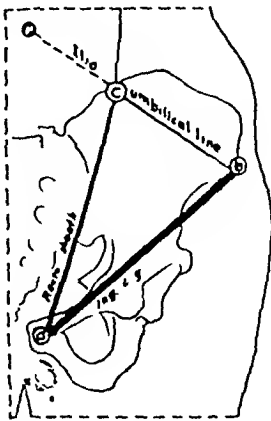


Fig 1 Major superior triangle

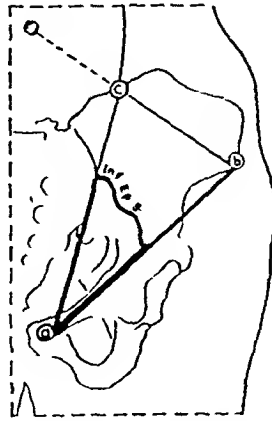


Fig 2 Intermediate triangle (Hesselbach)

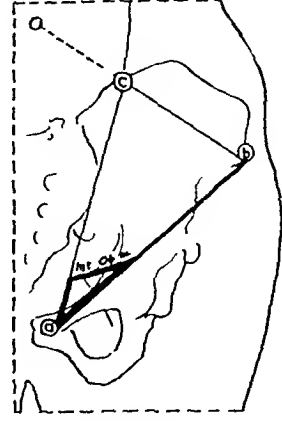


Fig 3 Medial triangle

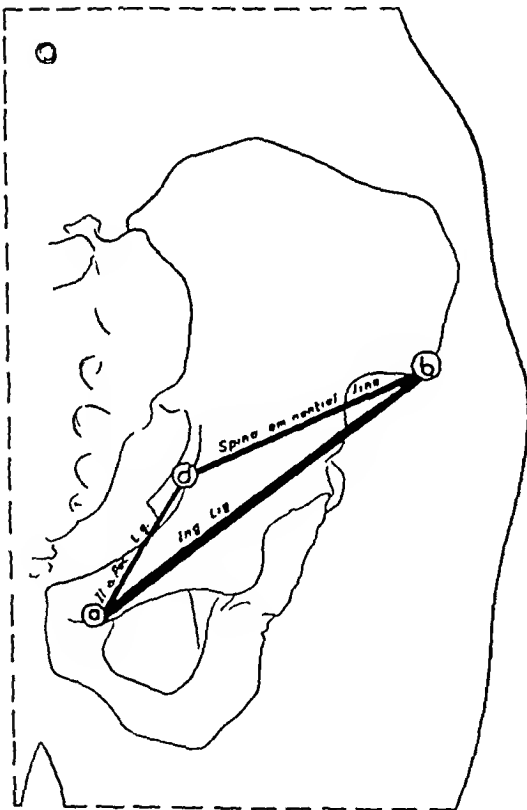


Fig 4 Major inferior triangle

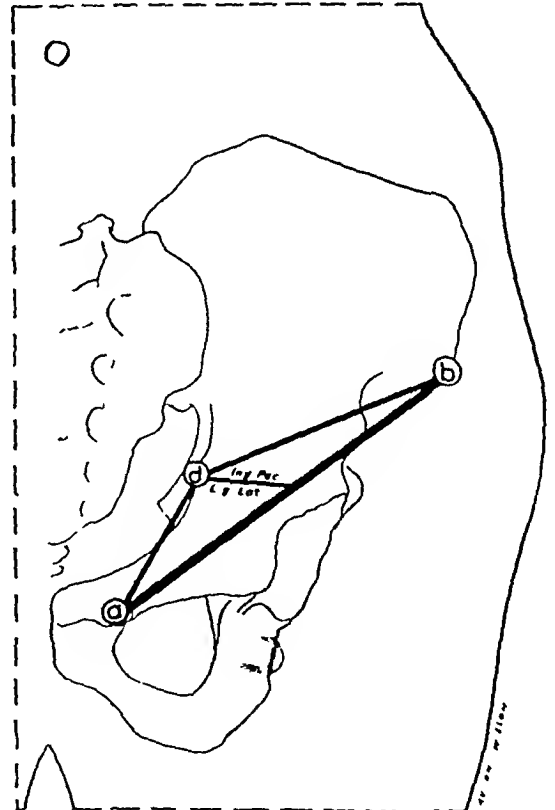


Fig 5 Vascular and muscular triangles

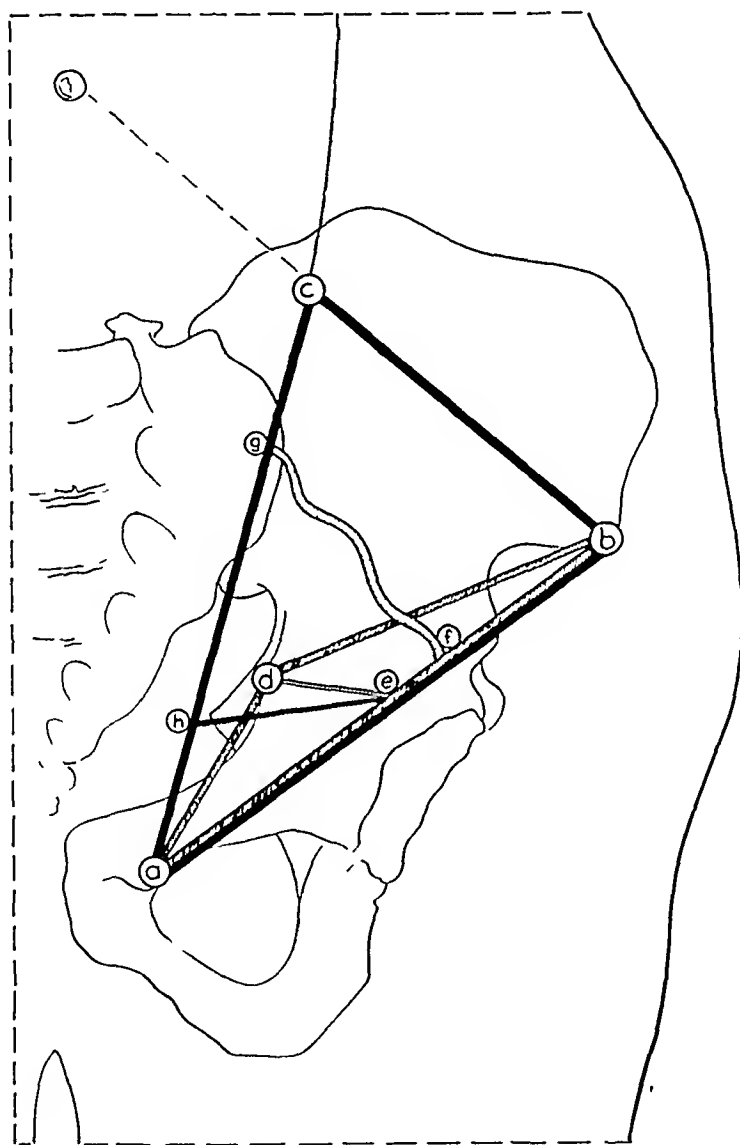
a Pubic tubercle
b Anterior superior spine

c Junction ilioumbilical line
and rectus sheath
d Iliopectineal eminence

PLATE I

and medial to the inguinal ligament is concerned with the development and treatment of femoral loculations of the sac and received little surgical con-

sideration until the publications of Moschcowitz,⁸ Seelig and Tuholske,⁹ Payne,¹⁰ Dickson¹¹ and Wilmoth¹² The recognition and correlation of these superior and inferior major triangular units in the repair of coexisting inguinal and femoral hernias, can hardly be overemphasized Formerly,



a b c MAJOR SUPERIOR TRIANGLE
a f g Intermediate triangle
a e h Medial triangle

a b d MAJOR INFERIOR TRIANGLE
a e d Vascular triangle
b d e Muscular triangle

PLATE II

when saccular ligation at varying levels of the funicular canal was the extent of surgical procedure and when there was still no recognized plan of repair of the canal, triangular integration was of less strategic importance Therefore, in keeping with the proposed anatomic and surgical concept of the

inguinal region, a new classification of the triangles is described and illustrated which more nearly meets the basic anatomic principles upon which the various operative procedures may be founded

Anatomically, the inguinopectineal region or inguina should be considered as one large pyramidal area, which is divided by a common base, the inguinal ligament into an extrapelvic or major superior inguinal triangle and an intrapelvic or major inferior inguinal triangle

THE MAJOR SUPERIOR INGUINAL TRIANGLE (inguino-abdominal, inguino-hypogastric or inguinal trigone) (Plate I, Fig 1) refers to that area of the lower ventral abdominal wall bounded medially by the lateral margin of the rectus sheath, inferiorly by the inguinal ligament and superiorly by that portion of the ilio-umbilical line which is lateral to the rectus sheath. The superior inguinal triangle contains (a) the intermediate or Hesselbach's triangle (Plate I, Fig 2) which is the best known and first triangle to be described and (b) a smaller medial triangle (Plate I, Fig 3). It is through the latter that incipient direct hernias are first manifest. It will be noted that these three surgical triangles have common medial and inferior boundaries, the rectus sheath and inguinal ligament respectively, but their superior boundaries differ. The inferior epigastric vessels limit the intermediate triangle and the inferior margin of the abdominal component of the internal oblique muscle the medial triangle. Actually, the medial triangle occupies the cleft between the abdominal and cremasteric portions of the internal oblique muscle. This vulnerable angle, which is devoid of overlying muscle fascicles to augment the fascia transversalis, was recognized by Ferguson, who, before the turn of the century, devised means of overcoming this mural weakness. More recently (1934) Andrews and Bissell¹³ again directed attention to the importance of reinforcing this potentially weak area of the floor, which they designated the inguinal triangle, unfortunately adding to the already pre-existing confusion in the nomenclature of this anatomical region. Although the medial triangle is the smallest and is inconstant, it is unique in that it represents the pivotal area of weakness in the floor, marking the site of exit of all incipient direct hernias. This important anatomic fact and the need for its fascial reinforcement have not received the attention they deserve. Most textbooks of surgery emphasize or portray the site of emergence of internal or direct hernia as the intermediate or Hesselbach's triangle. Actually, on careful observation the initial exit of a direct hernia is in the medial triangle. This divergence of opinion is perhaps attributable to the frequent lack of opportunity to observe diminutive direct hernias at operation.

Most direct hernias when seen at operation are advanced and frequently occupy all of Hesselbach's space. At times, the protrusion may even displace the epigastric vessels laterally until they are at the level of the abdominal inguinal ring. In this case, a large direct sac obtains and the entire floor of the canal has been enfeebled by the pistoning action of the hernial mass. Coincident with this expanding hernia there is progressive enlargement of

the medial triangle until it is converted into and occupies the space normally occupied by the intermediate triangle

Conversely, an enlarging indirect sac may displace the inferior epigastric

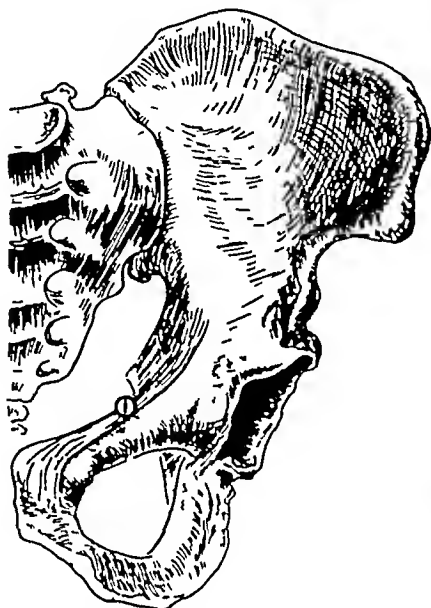


Fig 1 Iliopectineal ligament (1)

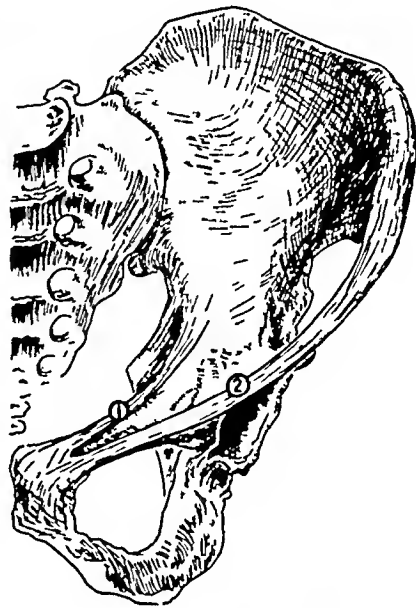


Fig 2 Inguinal ligament added (2)

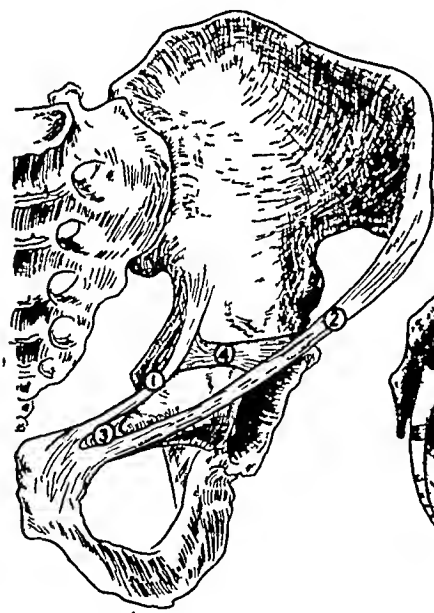


Fig 3 Inguinopectineal ligaments
medialis (3) and lateralis (4) added

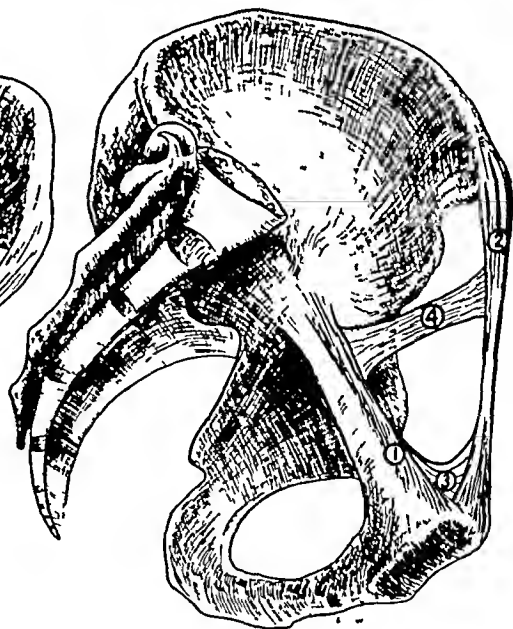


Fig 4 Composite of preceding ligaments,
medial view

PLATE III

vessels medially until they come to lie under the rectus sheath. In this instance, there no longer exists either an intermediate or medial triangular

space. However, despite these rare maximal distortional changes in the musculofascial structures, confusion should not exist and there should be no controversy over the triangular units if the normal anatomical boundaries are kept clearly in mind.

The major inferior triangle (Plate I, Fig. 4) comprises that space posterior and medial to the inguinal ligament and anterior to the bony pelvis. Its base or anterior boundary is the inguinal ligament (Plate III, Fig. 2) which is frequently referred to as the femoral or subinguinal region. The spinoeminential line which extends from the anterior-superior iliac spine to the pectineal eminence constitutes the posterior-superior boundary, and the iliopectineal line the posterior-inferior boundary of the triangle. This large inferior triangle is subdivided by the ligamentum inguinopectineale lateralis (Plate III, Fig. 3 and 4) into two smaller ones, the vascular and the muscular (Plate I, Fig. 5).

The vascular triangle is of much greater importance surgically. It occupies the interligamentous space or that area between the inguinal and iliopectineal ligaments. It is the more vulnerable triangle and represents the site through which the various types of femoral sacculations become manifest. Laterally, this triangle is limited by the ligamentum inguinopectineale lateralis which also separates it from the muscular triangle. Incidentally, this ligament is referred to as the iliopectineal in Callander's and Morse's textbook of anatomy, but actually it does not arise from the ilium superiorly but from the inguinal ligament and therefore it should be called the inguino-pectineal ligament. Similarly, the smaller ligament spanning the gap between the inguinal and iliopectineal (Cooper's) ligaments medially should be designated ligamentum inguinopectineale medialis (Plate III, Fig. 3 and 4) instead of lacuna of Gimbernat's. An even more glaring confusion exists in regard to the naming of Cooper's ligament (Plate III, Fig. 1) which extends from the iliopectineal eminence along the pecten of the superior pubic ramus to the spine of the pubis and is variously named pubic, superior pubic, pectineal and iliopectineal. Without entering into the historical controversy concerning Cooper's ligament, it is our contention that iliopectineal is the more descriptive term and the preferable designation, since it overlies and is intimately adherent to the uncontested iliopectineal line.

The muscular triangle is bounded anteriorly by the superior half of the inguinal ligament and posteriorly by the spinoeminential line. This line is depicted as straight on the drawings but is somewhat wavy in its proximal portion, corresponding to the anterior edge of the ilium. The inferior boundary of this triangle is formed by the ligamentum inguinopectineale lateralis. There are no normal apertures or potentially weak areas in this triangle as it is well fortified muscularly and herniations through it are exceedingly rare. It is included in the composite anatomic unit because occasionally pedicled fascial grafts are transferred through this triangular space to replace the inguinal ligament or to reinforce maximal attenuation of the fascia transversalis. By referring to Plate II it will be noted that the

muscular triangle differs from the other triangles of the inguina in that its apex is at the anterior-superior spine of the ilium, whereas the apices of the other five triangles (major superior inguinal with its component middle and medial triangles and the major inferior with its component vascular triangle) are at the pubic spine and all of these triangles have a common base, THE INGUINAL LIGAMENT

THE PARIETAL WALL

The paries of the superior inguinal triangle (inguinohypogastric region) with the exception of slight fascial variants do not differ from the stratification of the lateral abdominal regions which is composed of three musculo-aponeurotic layers. Each muscle stratum is enveloped by fasciae which fuse with the tendinous or aponeurotic plate lateral to their conjunction with the rectus sheath. Inferiorly the respective fasciae continue their descent into the scrotum, contributing the three strata of the funicular tube or canal. Generally, the transparietal portion of the canal is spoken of as the inguinal canal, whereas that portion caudal to the external ring is referred to as the extra-parietal or scrotal portion of the funicular canal.

The external or most superficial stratum of the abdominal wall is the external oblique muscle. The fascicular and tendinous portions of this muscle are the most constant in their proportions. Its broad aponeurosis stretches downward and is inferomesial to the anterior-superior iliac spine. In its inguinal portion is a triangular rent forming the external inguinal ring for the passage of the cord. The aponeurotic fault between the divergent crura is reinforced with arching membranous strands of connective tissue which arise from the fused epimysium and investing fasciae. The conjunction of the external oblique aponeurosis with the rectus sheath is medialmost of the three abdominal layers. The anterior and posterior enveloping fasciae of this muscle extend inferiorly and conjoin to form the external spermatic fascia. Laterally, the aponeurosis of this muscle is transformed into the inguinal ligament. The reflection of the lowermost fibers of the inguinal ligament at the inguinopectineal junction is usually demonstrable as thin, arching strands of connective tissue overlying the medial portion of the internal oblique muscle and are variously referred to as the triangular fascia, Colle's fascia, or ligamentum inguinale reflexum. This ligament makes an excellent anchorage for the first suture in the closure of the medial angle of the floor. Bisgard¹⁴ has especially stressed the importance of this ligament in reinforcing the vulnerable angle of the canal. The length, constancy and uniform density of the external aponeurosis have made it a frequent contributor of single and occasionally multiple pedicled sutures, notably in the McArthur,¹⁵ Robins,¹⁶ Sachs,¹⁷ Carscadden¹⁸ and Joyce¹⁹ techniques.

The internal oblique muscle and its ensheathing fasciae constitute the second or intermediate layer. While there may be considerable differences in its fascicular and aponeurotic components usually its medial third is tendinous. A frequent variation is its point of insertion onto the rectus

sheath at a variable distance from the pubic tubercle. This anomaly produces a triangular gap between the abdominal and cremasteric portions of the muscle. This vulnerable area in the floor of the canal was recognized by Ferguson, Halsted,²⁰ Bloodgood²¹ and Andrews as a frequent predisposing factor in the formation of direct hernia. The older anatomies and surgical literature refer to the conjoined tendon, meaning the union of the aponeuroses of the internal oblique and transversus muscles with resultant formation of a common aponeurotic plate, however, currently this concept of aponeurotic fusion is not accepted by many anatomists (Anson, Morgan, McVay and Ashley). Suffice it to say, there has been sufficient anatomic research in recent years to support the view that the aponeuroses of the middle and inner strata actually do not conjoin, but in spite of this factual evidence the term "conjoined tendon" has been so long in use to connote a definite structure that it is not likely to be abandoned soon. An underlying accessory internal oblique muscle has been described by Tuholske and McVay and which occurs with sufficient frequency that to avoid possible confusion with the transversus abdominis its existence should always be suspected. The tendinous component of the internal oblique blends with the rectus sheath lateral to that of the external oblique muscle. Inferiorly, the enveloping fasciae of this muscle unite to form the cremasteric or middle layer of spermatic fascia.

The transversus abdominis muscle is the most deeply placed of the three parietal layers of the superior inguinal (inguinohypogastric) region. Owing to the variability of its fascicular, aponeurotic and fascial components, it has been and still is a perpetual source of controversy among anatomists. Naturally, this anatomic disagreement has resulted in a lack of unanimity as regards its surgical significance in the treatment of hernia. The muscle fascicles almost never extend inferiorly beyond the level of the abdominal inguinal ring and at this level they may be tendinous. Moreover, its transition from muscle to aponeurosis to fascia may be gradual or abrupt and may vary in density. Where there is arching of the aponeurosis, particularly if there is concomitant thickening, it is frequently referred to as the aponeurotic inguinal falx or conjoined tendon. The investment fascial coverings of this muscle do not differ from that of the other flat muscles.

The fascia transversalis is subadjacent and contiguous to the deeper stratum of the investing fascia of the transversus abdominis. It is currently interpreted as a distinct fascial lamina lining the inner surface of the abdomen. Almost a century and a half ago the anterior fascia was described and illustrated by Cooper in 1804 and in a subsequent edition of his book is referred to as the fascia transversalis. Zieman²² considers this fascia as an intrinsic investing fascia of the abdominal wall and lining the abdominal cavity including the pelvis and the caudal surface of the diaphragm. A similar interpretation is implied by Dickson, who introduced the term endo-abdominal fascia. Similarly, Biowne has given the same fascial lamina the name of abdominal connective tissue. The older anatomies (Shaw, 1825) refer to this fascial stratum as fascia longitudinalis, or reflexa of M. Cloquet

The meticulous dissections of Anson have corroborated the broader concept of the fascia transversalis. Despite the varying evolutionary interpretations of this fascial layer, from a surgical standpoint it should be considered the deepest fascial layer of the abdominal wall which is intimately related to the internal fascial bed of the transversus abdominis. These contiguous fascial layers are employed surgically as a single fascial plate. In the inguinal canal this internal parietal stratum is devoid of muscle fascicles caudal to the internal abdominal ring but possesses pivotal reparative value unless it has become attenuated by the hernial mass. The fascia transversalis continues laterally bridging the interligamentous space, and posteriorly encasing the femoral vessels, contributing to the reinforcement of the femoral ring before its insertion into the iliopectineal (Cooper's) ligament. With its extension caudally it becomes the internal spermatic fascia. In its medial course it splits, contributing to the formation of the anterior rectus sheath and the posterior rectus fascia. The latter should not be confused with the posterior rectus sheath. The transversus aponeurosis in its approach to the rectus muscle changes from bilaminar to unilaminar stratum at the semicircular line about 8 cm from the symphysis pubis. Inferior to this transitional line there is no posterior sheath, only a membranous film of rectus fascia. In the inferior segmental zone the aponeurotic fibers conjoin and run exclusively anteriorly to the rectus muscle, blending with the rectus sheath.

The difference of opinion regarding the reparative value of the mural strata has invariably centered on the innermost layer, the transversus aponeurosis and fascia from which arise so many ligamentous or equivocal fascial variants. The dividing structure between direct and indirect hernia has long been accepted as the inferior epigastric vessels. Bowme has challenged the strategic importance of these vessels and has pointed out that unsupported blood vessels have not the tenseness and rigidity which would enable them to act in this way. It is his contention that the condensation of fibers of the fascia transversalis which accompanies the vessels resists the progression of the pantaloon sac and separates the two major types of sac. It is the same band of connective tissue described by Hesselbach and is occasionally referred to as the internal crus of the internal abdominal ring. Some textbooks have named this fascial variant the interfoveolar ligament and ascribe its source to aberrant strands of muscle fascicles which have strayed from the transversus abdominis. Quain²³ shows an apparently identical structural departure superficial to the tissues bounding the internal ring and floor of the inguinal canal, but superimposes additional confusion by illustrating these tissues as continuous with the transversus aponeurosis and calling them the iliopectineal tract. The anatomic dissections of Clark and Hashimoto²⁴ have corroborated the existence of the iliopectineal tract and have revived Henle's ligament. They claim the latter arises from the lowermost portion of the rectus sheath and adjacent portion of the transversus aponeurosis. Inferomesially it blends with the iliopectineal tract, a tough fibrous structure which is below and separate from the inguinal ligament. Briefly,

it would seem that while these fascial variants may be demonstrable, they are inconstant and to ascribe to them a strategic role in the fascial repair of the canal is exaggerating their significance. The error lies in overemphasizing aberrant fascial planes to the exclusion of the more important reparative problem comprising the whole floor of the canal and forgetting there are many predisposing anatomic factors in the genesis of initial and recurrent hernias.

COMMENT

Although basic but not wholly new, the unorthodox triangulation and proposed anatomical concept of an extra-pelvic and an intra-pelvic inguinal region would gain naught unless transposed into practical surgery. In considering reparative surgery of this region it is essential to redefine the loosely used term "defect" as contrasted with "weakness" if there is to be a composite understanding of the criteria and the reparative maneuvers employed in the fascialization of the floor of the canal. A defect in the wall conveys the erroneous idea that there exists a concentric aperture in an otherwise architecturally normal wall, a presumption which is rarely seen at operation except in the presence of interfascicular rents. Similarly, weakness may imply laxity of the wall or it may connote marked stretching with thinning of the fascia transversalis and internal oblique fibers until there no longer exists a homogeneous structure of strategic value. Where the latter obtains and the floor is membranous, its replacement is essential to the creation of an unyielding wall.

Assuming there is weakness of the entire extent of the canal with coexisting saccular protrusions, the strategy should be to form a resistant fascial diaphragm for the entire floor which in some instances is augmented by anchoring the cranial margin of the fascia transversalis to the iliopectineal ligament. Herein lies the advantage of a thorough understanding of the composite anatomy of the inguina.

The horizon of hernia repair has been decidedly increased by the proposed concept of triangulation and by the adoption of the superior inguinal approach for all hernias in the intrapelvic and extrapelvic triangles. This approach commands a more comprehensive view of the important ligaments and vessels, gives greater access to the intrapelvic hernia-bearing area and facilitates exposure of the iliopectineal ligament, which, if used for pivotal anchorage, achieves a more deeply placed parietal barricade.

CONCLUSIONS

The advantages that may accrue from a uniform and acceptable terminology of the mural and ligamentous structures of the inguinopectineal region have been discussed and re-emphasized.

A new concept of the inguina or hernia-producing region has been presented, which embodies the formerly recognized inguinal and femoral regions.

The inguina has been defined and portrayed as a pyramidal space consisting of a superior or extra-pelvic triangle and an inferior or intrapelvic

triangle, which are respectively divided into smaller anatomical triangular units

Triangulation of the inguina does not conflict with existing basic anatomic concepts

The erroneous but prevailing concept of defect as contrasted with weakness as it applies to plastic repair has been discussed

The strategic advantages of the superior or inguinal approach over the inferior or femoral have been pointed out

Attention has been directed to the value of an exclusively fascial stratification

In the presence of a multiple locular sac, inadequacy of the inguinal ligament or diffuse parietal laxity, the iliopectineal (Cooper's) ligament hernioplasty is preferable

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THYROIDITIS

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THERE ARE THREE MAIN AND DISTINCT CLINICAL TYPES of thyroiditis, (1) subacute (pseudo-tuberculous or giant cell) thyroiditis, (2) struma lymphomatosa (Hashimoto's thyroiditis), and (3) Riedel's struma (woody or ligneous thyroiditis). There are other types of thyroiditis that either have not been classified or represent incomplete or atypical forms of the above. In addition, thyroiditis may complicate bacterial or virus infections and may be the result of parasitic disease. It is not within the scope of this paper to discuss the rare and atypical types of thyroiditis but rather to define more clearly the recognized types and to discuss their treatment.

SUBACUTE THYROIDITIS (27 CASES)

Subacute thyroiditis is a self-limited disease of unknown etiology. It runs a variable course of weeks or months and eventually subsides without treatment and without significant interference with the function of the thyroid.

This type of thyroiditis has been variously named tuberculous, pseudo-tuberculous, or giant cell thyroiditis because of the histologic appearance of pseudotubercles with giant cells. Tubercle bacilli cannot be demonstrated in the lesions, and the etiology of the disease is unknown. Bacteria have not been demonstrated in the thyroid. The possibility that it represents a virus infection has not been excluded. The pseudotubercle or giant cell reaction represents a reaction of wandering cells to colloid, which they appear to be phagocytizing.

Many surgeons do not operate on patients with subacute thyroiditis and hence are not aware that this well-recognized clinical entity is, from the histologic standpoint, identical with pseudotuberculous or giant cell thyroiditis. In order to prove to my own satisfaction that the two diseases are the same I have analyzed 15 cases of subacute thyroiditis in which roentgen treatment was given and compared the history and physical findings with those of 12 cases in which operation was performed. To further confirm the fact that the clinical entity of subacute thyroiditis is indeed identical with the pathologic entity of giant cell or pseudotuberculous thyroiditis, biopsies of the thyroid were taken in two typical cases of subacute thyroiditis, and the patients were then treated with roentgen-ray. The biopsies showed typical giant cell or pseudotuberculous thyroiditis, the response to roentgen-ray was prompt, complete, and typical of that of subacute thyroiditis. In the table the two groups are compared, and it is clear that the cases are similar in most respects, the only difference being that the cases treated surgically were in general less acute and of longer duration. Many of these cases probably represent the subsiding phase of the disease.

Clinical Course The onset of subacute thyroiditis is usually sudden and in about a fourth of the cases follows an acute upper respiratory infection. This history is difficult to evaluate because patients cannot invariably differentiate between a sore throat and a sore thyroid gland. It is six times more common in women than in men and tends to occur in the mid-forties.

Pain on swallowing and pain radiating up to the ear are characteristic of subacute thyroiditis. Usually the gland is exquisitely tender. A low grade elevation of the temperature is present (Fig 1) and the sedimentation rate is elevated, often to high levels. There may be a marked systemic reaction.

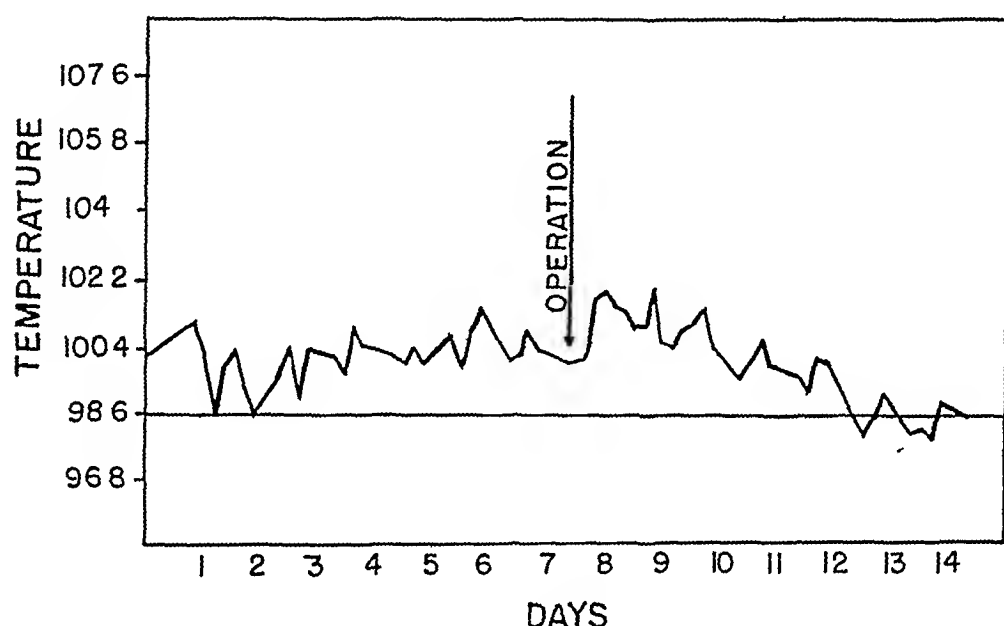


FIG 1—Temperature chart of patient with subacute thyroiditis. Before admission to hospital she had been observed for two months and had not improved. Only one lobe of thyroid was removed, but temperature and pulse rate fell promptly to normal.

The patient feels nervous, weak, and tired, and the pulse rate is elevated out of proportion to the temperature, sometimes as high as 160. Sweating and tremor are often prominent symptoms, so that the clinical picture may closely simulate hyperthyroidism. The basal metabolism, however, is not often elevated above the upper limits of normal and it is questionable whether true hyperthyroidism is present. The average basal metabolic rate is $+10$, but about one-third of the patients have basal metabolic rates over $+15$ per cent. The picture is that of a toxic reaction rather than of true hyperthyroidism. There is usually loss of weight, but since the duration of the disease is short the loss is slight. The eye signs of hyperthyroidism are not present.

Tenderness of the thyroid is almost always present, especially in the early stages when the gland is exquisitely sensitive to pressure. The entire gland is diffusely involved in most cases. Its consistency is abnormally firm or hard. Occasionally the process will start in one lobe and spread gradually to involve the entire gland ("creeping" type of thyroiditis).

The diagnosis of subacute thyroiditis usually is unmistakable and is suspected from the first. In only six of the 27 cases was the diagnosis missed by the first examiner.

The natural course of the disease appears to be toward spontaneous recovery without permanent derangement of the function of the thyroid. This course is shortened by thyroidectomy, roentgen-ray therapy, or it is said,¹ by treatment with thiouracil. This type of thyroiditis does not go on to either Hashimoto's or Riedel's disease, nor, in our experience, has supuration occurred.

Pathology Subacute thyroiditis is characterized by a diffuse involvement of the entire thyroid in a subacute inflammatory process. There is infiltration with leukocytes and numerous foreign body giant cells are present. The arrangement in formations somewhat resembling tubercles gives rise to the name pseudotuberculous thyroiditis. The foreign body reaction is probably a response to the colloid in the degenerating follicles, and histiocytes can be seen phagocytizing this material.



FIG 2—Gross appearance of subacute thyroiditis. The small adenoma at the upper pole is an unusual finding.

The thyroid rarely contains adenomas. The glands are not enlarged to more than two or three times their normal size, and the enlargement tends to be symmetrical. The cut surface of the gland is white and avascular. It is

quite brittle and will not hold a hemostat. The capsule is only very lightly adherent to surrounding structures, and there is no tendency to infiltration and fixation, as in Riedel's struma. Tubercle bacilli have not been identified in this lesion (Fig 2).

Treatment Subacute thyroiditis responds promptly and completely to roentgen-ray therapy. Six hundred to 800 r usually suffice to effect a resolution in a few weeks. The pain and tenderness subside in a few days. The average time at which 15 patients treated with roentgen-ray were considered to be entirely well was 19 days after the start of treatment. By this time the thyroid is rarely either tender or palpably enlarged. In two of our cases, two or more courses of therapy over a period of three months were required before a complete cure was effected. Three patients considered themselves well in one week.

One patient developed a severe systemic reaction to an undulant fever skin test, and this was accompanied by an exacerbation of the pain and tenderness in the thyroid and was followed by complete resolution of the thyroiditis in a matter of a few days. Whether this was a specific or nonspecific

THYROIDITIS

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TABLE I

	Reidel's Struma 11 Cases Treated by Partial Thyroidectomy	Struma Lymphomatosa 14 Cases Treated by Partial Thyroidectomy*	Subacute Thyroiditis 15 Cases (14 treated with roentgen-ray and 1 by undulant fever vaccine)	Giant Cell or Pseudotuberculous Thyroiditis 12 Cases Treated by Partial Thyroidectomy
Age	42 to 74, av 51 (7 over 50) 10 F, 1 M	30 to 72, av 49 (8 over 50) 12 F, 2 M	20 to 61 Av 41 14 F, 1 M	34 to 57 Av 47 9 F, 3 M
Sex	3 mo to 7 yrs Av 29 mo (8 were 1 yr or more)	1 mo to 8 yrs Av 20 mo (7 were 1 yr or more)	Few days to 6 mos Av 6 wks	3 wks to 11 mos Av 11 wks
Duration	Pressure 6, goiter 2, nervousness 1, pain 2	Goiter 7, systemic symptoms 4, pressure 3 (pain at onset only 3)	15 pain in thyroid	Pain 11, no pain 1 (systemic symp- toms)
Leading symptom	1 1 0	1 at onset only 0	15 12, no pain none, no statement 2 6, no ear pain 2, no statement 7	10, not tender 2 5, no pain 4, no statement 3 6, no statement 6 98 4° to 102 5° Av 99 9° (4 over 100°)
Tender thyroid	1	0	97 8° to 101° Av 99 4° (5 had temp over 100°)	96 to 152 Av 108 (2 had pulse over 120)
Pain on swallowing	1	Av 98 6°	72 to 160 Av 113 (6 over 120)	0 to 30 lbs Av 13 lbs -13 to +41 Av +10
Pain radiating to ear	0	64 to 128, av 86	0 to 12 lbs Av 6 lbs -19 to +29 Av +10	4 cases average 0 96
Temperature	Av 98 7°	Av 6 lbs -24 to +18, av -8%	8 cases average 1 46 mm/min (normal 0 4)	9 recognized before op, 3 not recog- nized
Pulse rate	80 to 120, Av 88	1 case 0 22	15 correct diagnosis	12, unilateral 0
Loss of weight	Av 9 lb -20 to +28, av +2%	Thyroiditis 3, nodular goiter with- out hyperthyroidism 9, calcified adenoma 1, carcinoma or thyroid- itis 1	12, unilateral 3 (creeping type 2)	2 cases, both neg None in 7, questionable in 5
B M R	1 case 1 6	Thyroiditis 2, ca or Riedel in 2, adenoma 1, ca in 6	Neg 4, strongly pos 1, weakly pos 1 None in 12, questionable in 3	4
Sedimentation rate		5, unilateral 6 (2 of unilateral later involved the other lobe)	3	12 (2 had associated adenomas)
Diagnosis preop		None tested None 1 questionable	2 (biopsy only)	0
Bilateral		11 (7 had associated adenomas)	14 cases 300 to 1050 r Av 620 r Well 1 wk to 3 mos Av 19 days, all improved in 3 wks	Thyroidectomy 6, 5 well postop Hypothyroidism 1
Und fever skin test		3 cases, 2 with apparent arrest but no regression, 1 with no improve- ment after 2550 r	Lobectomy 0 Biopsy 2	Lobectomy 6, 3 well post op, 3 had symptoms due to persistence or re- currence in other lobe but eventually recovered
Hyperthyroidism		Removal of part of each lobe 4, 3 pts well, 1 hypothyroidism postop		
History of upper resp infect at onset		Removal of part of 1 lobe 7, 3 pts well, 2 developed recurrences in other lobe, 1 had persistent tumor		
Proved by exam of tissue		other lobe, 1 had persistence of in other lobe, 1 had persistence of spontaneous preop tetany resulting from destruction of parathyroids by fibrosis		
X-Ray therapy		2 pts developed spontaneous paral- ysis of vocal cord on affected side	No laryngeal paralysis	No preop Paralysis
Surgery				
Larynx				

*6 of the cases included in this series were previously reported by Dr Allen Graham, ref 2 8 are unreported cases

reaction to the undulant fever vaccine will never be known. Eight other patients had negative and one a weakly positive skin test for undulant fever.

Thyroidectomy is a satisfactory means of controlling subacute thyroiditis, but since the disease is essentially self-limited and since roentgen-ray effects such prompt and complete resolution, operation is not often indicated. Most of the patients reported here as having been subjected to operation were seen before we recognized the value of roentgen-ray.

Thyroidectomy was performed on six patients, five of these are well and one has developed hypothyroidism.

A single lobe was removed in six cases. Three of these patients developed a recurrence or suffered from persistence of symptoms due to involvement of the remaining lobe. All eventually recovered.

Since roentgen-ray has given entirely satisfactory results we have not used thiouracil in the treatment of subacute thyroiditis. If the foreign body reaction is indeed due to the presence of colloid, the beneficial action of thiouracil could be explained on the basis of its interference with the formation of this substance.

Case 1—Subacute (pseudotuberculous or giant cell) thyroiditis

The patient was a woman 32 years old. Two months before entry she had noted sudden onset of pain in the right side of the neck. This area was tender. There was palpitation, insomnia, nervousness, and an elevation of temperature to over 100°. She had lost six pounds in weight. Iodine had been given without improvement.

Examination showed a diffuse enlargement of the entire thyroid to one and one-half times the normal size. Both lateral lobes and the isthmus were stony hard and tender. The temperature was 99.6° and the pulse 108. There was a coarse tremor and the skin was dry. There were no eye signs of hyperthyroidism. The basal metabolic rate was +3 per cent.

A biopsy, 2 mm in diameter was taken from the isthmus of the thyroid and the pathologist reported chronic thyroiditis with marked granulomatous reaction to colloid (so-called pseudotuberculous thyroiditis). There was a fairly marked increase in connective tissue with the remaining follicles of small or medium size formed of flat or cuboidal epithelium, fairly well filled with colloid, and with some of the follicles partly filled by cells of the histiocyte or macrophage type. Colloid was markedly reduced or absent in the follicles containing these cells. Also present were fairly frequent accumulations of mononuclear cells and foreign body giant cells which in several instances enclosed small lakes of colloid. The stroma contained a slight to moderate infiltration of lymphocytes and some plasma cells and polymorphonuclear leukocytes (Fig. 3).

A total of 700 r of roentgen-ray was then given to the thyroid area in five treatments distributed over a period of nine days. At the end of this time the patient stated that she felt entirely well. There was no pain or tenderness of the thyroid, and the gland had returned to normal size, but the right lobe was still fairly firm. The consistency of the left lobe was normal.

Four weeks later the thyroid was soft and barely palpable, and the patient remained well.

Comment. The clinical features of this case and the response of the thyroid to roentgen-ray treatment are typical of those encountered in other cases of subacute thyroiditis. Biopsy of the thyroid showed changes characteristic of the so-called pseudotuberculous or giant cell thyroiditis. In a sec-

ond case subjected to biopsy the clinical course and response to roentgen-ray therapy were similar, and the pathologist reported a similar lesion in the thyroid. There can be little doubt that the clinical disease, subacute thyroiditis, is, from the pathologic standpoint, pseudotuberculous or giant cell thyroiditis. This disease responds promptly to roentgen-ray treatment and does not necessitate thyroidectomy.

STRUMA LYMPHOMATOSA (14 CASES)

Struma lymphomatosa is a progressive disease of the thyroid, possibly associated with systemic disorders,² in which there is extensive acidophilic degeneration of the epithelial elements of the thyroid and replacement by

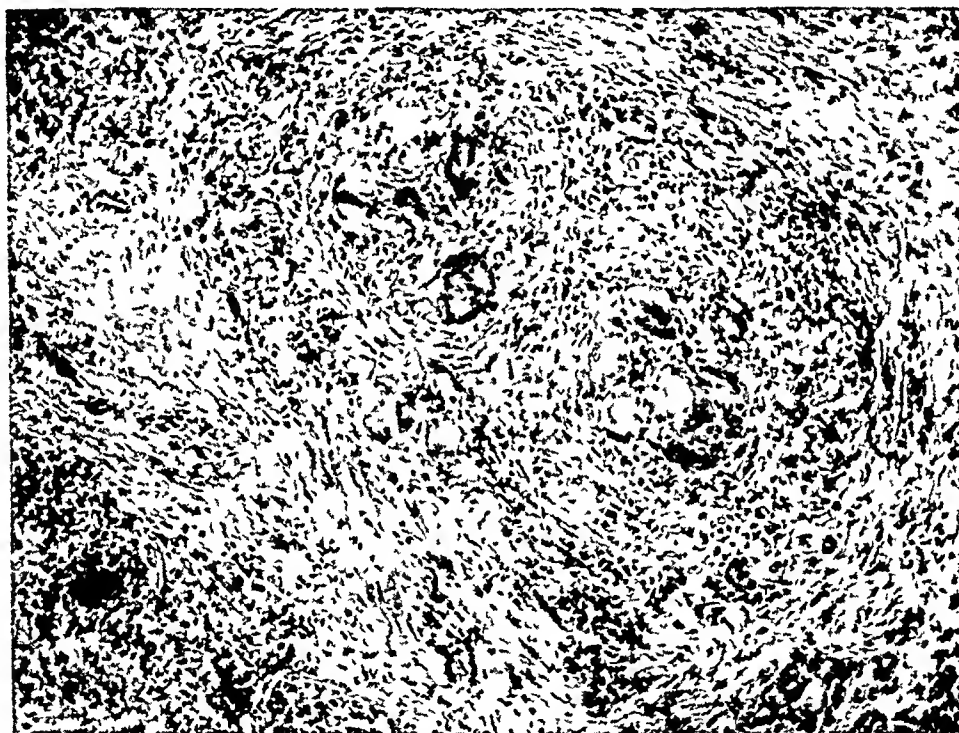


FIG 3—Subacute or giant cell thyroiditis. Biopsy obtained in case 1. Prompt and complete resolution following x-ray treatment ($\times 50$).

lymphoid and fibrous tissue. Hypothyroidism or at least a peculiar type of hypometabolism that does not always respond specifically to desiccated thyroid is apt to develop. The etiology of the disease is unknown. It does not progress to Riedel's struma³ nor is it the end result of subacute thyroiditis. An excellent description of this disease was given by Joll in the *British Journal of Surgery* in 1939.⁴

Clinical Course. Struma lymphomatosa occurs most commonly in the late forties or early fifties. Although it is rarely seen in men, two such cases are reported in this series.

True struma lymphomatosa is rare and is not to be confused with lymphoid infiltration of the thyroid or nonspecific types of lymphoid thyroiditis, from which it can be distinguished by the acidophilic degeneration of the epithelium. True Riedel's struma usually is somewhat more rare than struma

lymphomatosa In my experience Riedel's struma and struma lymphomatosa are only about one-fifth as common as subacute thyroiditis In the course of approximately 900 thyroidectomies I have records of two operated and 15 unoperated cases of subacute thyroiditis, three operated cases of struma lymphomatosa, five operated cases of Riedel's struma, and one of suppurative thyroiditis, as well as several cases that are unclassified

The onset of struma lymphomatosa is insidious, and pain is noted only rarely at the onset None of our patients had pain radiating to the ear, and only one had noticed pain on swallowing The glands are not tender, there is no fever, and rarely is there any systemic reaction except that associated with hypothyroidism and a peculiar lack of feeling of well-being which does not always respond to treatment either by thyroidectomy or by administration of desiccated thyroid It is interesting to note that in the only two patients who had gastric analyses there was no free acid Graham observed anacidity or hypoacidity in six of his 14 cases In one patient who died, postmortem examination showed generalized lymphoid hyperplasia Mild anemia may be present ²

Half of the patients in this group complained merely of goiter Four had systemic symptoms such as nervousness or loss of weight, and three complained of pressure symptoms from the enlarging gland There was no consistent elevation of the temperature or pulse rate, and the basal metabolic rates averaged -8 per cent In five of the 14 cases the basal metabolic rates were less than -10 per cent, -24 being the lowest

The average duration of the goiter or of the symptoms prior to operation was 20 months The sedimentation rate was normal in the only patient in which this was tested

The entire gland usually is involved In two cases it was stated that only one lobe was involved, but biopsies were not taken from the other lobe The glands were described preoperatively as firm and "adenomatous" It is noteworthy that the gland does not appear to be so symmetrically involved in struma lymphomatosa as in subacute thyroiditis Certain areas may enlarge more rapidly than others, giving a firm irregularity which in the majority of cases suggested the diagnosis of adenomatous goiter without hyperthyroidism Once a calcified adenoma was suspected, once carcinoma or thyroiditis, and in only three cases was the diagnosis of chronic thyroiditis made before operation

In three cases the tumor had enlarged to the point of causing tracheal compression Most of the thyroids were four or five times normal size and when, as was occasionally the case, the growth encircled the trachea, symptoms of obstruction developed

There does not appear to be any tendency to spontaneous remission or cure of this disease One patient had had symptoms and an enlargement of the thyroid for eight years prior to operation McClintock⁵ has reported a case of struma lymphomatosa in which thyroidectomy was repeated two and a half years after the first operation and the histology of the gland was essentially unchanged

Pathology Graham² has said that there is no single clinical or pathologic feature of struma lymphomatosa that is characteristic or pathognomonic of this condition but that the entire clinical and pathologic picture, particularly the state of the thyroid gland as a whole, must be considered. Under these circumstances a fairly good case may be made out for either the Riedel or the Hashimoto type as a clinico-pathologic group, even if not an entity.

Struma lymphomatosa is characterized by acidophilic degeneration of the thyroid epithelium with replacement by lymphocytes and fibrous tissue. The lymphoid tissue often predominates and shows well developed germinal centers. There is no extension of the inflammatory process outside of the capsule and little or no tendency for the gland to become adherent to surrounding structures.

The thyroid is firm, friable, and not very vascular. Its cut surface is gray and lobulated and is sometimes mistaken for a hyperplastic goiter. Usually it is recognized as a thyroiditis at the operating table, but occasionally even pathologists fail to recognize it in the gross. The diffuse enlargement of the entire gland tends to form retrotracheal extensions which may render the gland difficult to deliver. In none of the 14 patients were there adenomas in the thyroid.

Treatment It has been said that roentgen-ray treatment affords an effective means of controlling this type of thyroiditis.⁶ Since we have rarely recognized the disease before operation we have not treated it with roentgen-ray. One patient was treated before she came to us by an unknown amount of irradiation without improvement.

Thyroidectomy was performed in 10 of the 14 patients. Three of the patients having thyroidectomy are well, five have hypothyroidism and require thyroid, one had a bilateral paralysis of the recurrent laryngeal nerves, and one died during operation with an unexplained convulsion. The high morbidity and mortality in this series suggests that conservative operations which do not attempt to remove all the gland may be preferable if the nature of the disease is apparent at the time of operation.

In four cases only a single lobe was removed. Two of these are well, one is improved, and one has a persistent enlargement of the other lobe but feels well. The record of lobectomy in this small group of cases appears to be better than that of thyroidectomy. Although roentgen-ray may be the treatment of choice, it will never be widely used unless the diagnosis can be made more often than it has been in the past. When struma lymphomatosa is first recognized during the operation it would seem best to perform a very conservative thyroidectomy, removing only enough of the isthmus and the lobes to relieve the pressure and leaving a moderate amount of thyroid tissue to help to prevent the development of hypothyroidism. This treatment is empiric and unsatisfactory, but unless we can establish the diagnosis before operation and until we know more of the etiology of the disease and of its response to roentgen-ray treatment it is the best available.

Case 2—Struma lymphomatosa (Hashimoto) The patient was a woman 50 years of age who had been under treatment for three years for symptoms assumed to be due to the menopause. One month before entry her physician had noted an enlargement of the thyroid. She had noted tachycardia and palpitation, nervousness, and dyspnea on exertion. She had lost 6 pounds in weight.

Examination showed the temperature to be 98.3°, pulse 80, and blood pressure 160/90. There was a nontender, movable mass 6 cm. in diameter in the right lobe of the thyroid and slight enlargement of the left lobe.

The basal metabolic rate was 0. The red blood cells numbered 4,000,000 and the hemoglobin was 88 per cent.

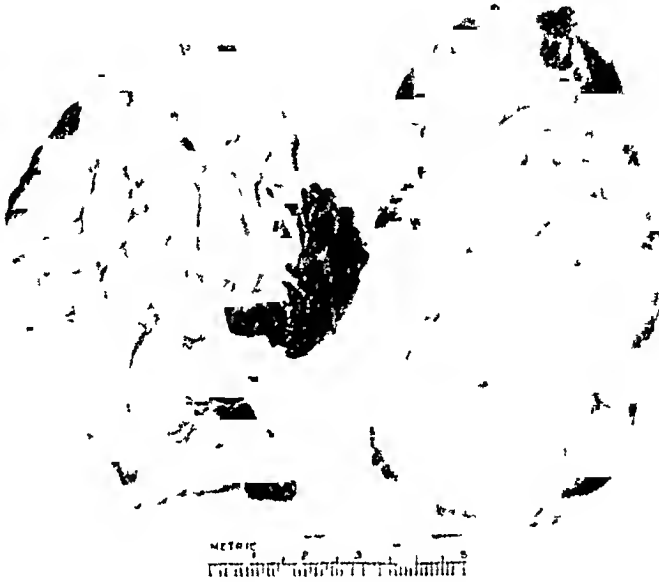


FIG 4—Gray color and lobulated appearance of struma lymphomatosa

The preoperative diagnosis was nodular goiter without hyperthyroidism. At operation there was found a firm nodular goiter involving chiefly the right lobe. The capsule was only slightly adherent. There was a large retrotracheal and retrosternal extension of the right lobe. The gland was vascular, pale and firm. A diagnosis of struma lymphomatosa was made, and nearly all of the right lobe and part of the left lobe were removed. The left lobe was not as large as the right.

The specimen consisted of the greater part of the right and left lobes of the thyroid and weighed 90 Gm (Fig 4).

The thyroid epithelium was hypertrophic and acidophilic and there was great variation in the size and staining reaction of the nuclei. The colloid was diminished. The thyroid tissue was lobulated with slight increase of interlobular stroma and considerable lymphoid tissue distributed diffusely throughout and present also in numerous large hyperplastic lymphoid follicles. There were many plasma cells present (Fig 5).

Convalescence was uneventful. Four months after operation the basal metabolic rate was -3 per cent, but the patient had the appearance of hypothyroidism and was given ½ gr. of desiccated thyroid daily. Fissures occurring at the corners of the mouth suggested a deficiency of vitamins.

Two years later the patient had no specific complaints but did not feel well. Thyroid feeding had not effected any improvement. Five years after operation the patient writes, "The effects of my operation are leaving me weak, but otherwise no trouble."

Comment This case is typical in that (1) the symptoms before operation were poorly defined and vague, (2) the presence of a goiter was the chief complaint, (3) the preoperative diagnosis was adenomatous goiter without hyperthyroidism, (4) the true nature of the disease was first suspected at the time of operation, (5) after operation clinical evidence of hypometabolism and vitamin deficiency were apparent but did not respond to treatment, and (6) the patient still feels weak five years after operation

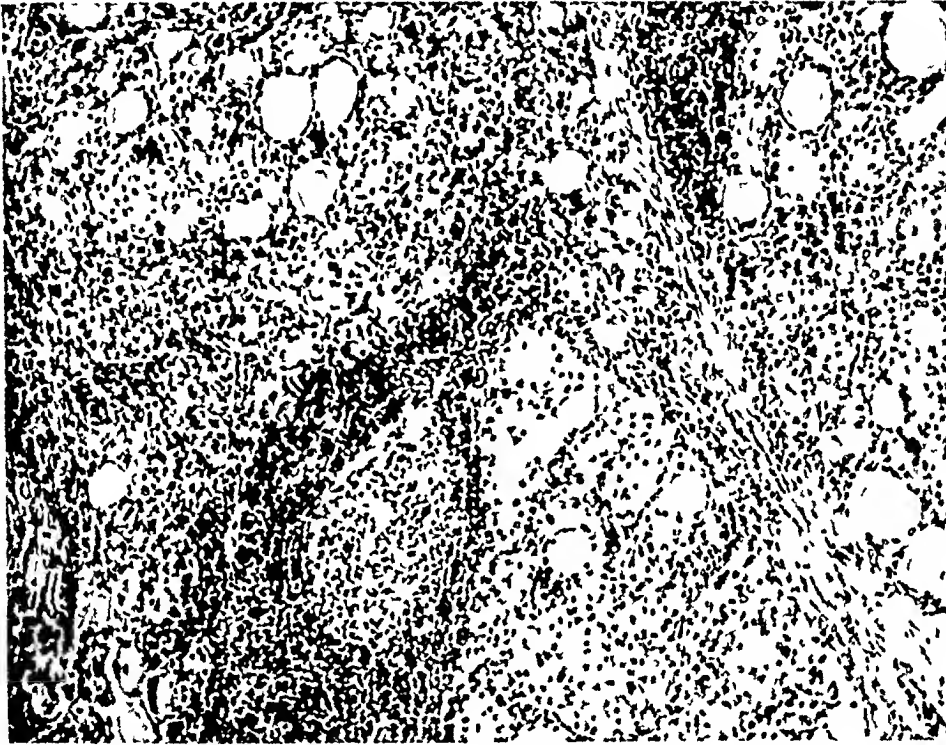


FIG 5—Case 2 Photomicrograph Struma lymphomatosa ($\times 50$)

RIEDEL'S STRUMA (11 CASES)

Riedel's thyroiditis is a chronic proliferating, fibrosing, inflammatory process involving usually one but sometimes both lobes of the thyroid and extending to involve the trachea and the muscles, fascia, nerves, and vessels in the vicinity of the thyroid. It produces a bulky tumor that may be indistinguishable preoperatively from an inoperable carcinoma. It is not the end result of either subacute thyroiditis or struma lymphomatosa but is a separate entity whose etiology is unknown. No specific organisms have been isolated from this lesion. In many instances the inflammatory reaction appears to center about a degenerating adenoma, and this may be a clue to its etiology.

Riedel's struma affects women more often than men and tends to occur beyond the age of 50.

Clinical course The onset is insidious and usually painless. In no case did the pain radiate to the ears, and only one of the patients had pain on swallowing. Tenderness was present only once.

The tumor grows slowly, the average duration of the enlargement having been 29 months before operation.

Symptoms of pressure predominated in over half of the cases and often were severe with tracheal obstruction. Two patients had a symptomless goiter, and one patient complained only of nervousness. The temperature and pulse rate are not often elevated, there are few if any systemic symptoms, and little weight is lost. The basal metabolic rate usually is normal (average $+2$ per cent) although in one case, with almost total destruction of both lobes of the thyroid, hypothyroidism was present and the basal metabolic rate was -20 per cent.

The sedimentation rate was moderately elevated in the only case in which it was tested.

Characteristically, the tumor in the thyroid is localized to a part of the gland. In two of the unilateral cases the other lobe eventually became involved in the same process, once after a few months and once several years later.

The thyroid is stony hard and fixed to the surrounding tissues. Only two cases were correctly diagnosed before operation. In six cases carcinoma was suspected, in two cases the examiner could not decide between Riedel's struma and carcinoma, and in one case the preoperative diagnosis was adenoma. In all cases the true nature of the lesion was recognized at the time of operation.

In two cases a unilateral paralysis of the recurrent nerve developed spontaneously.

Pathology In seven of the 11 cases adenomas or remnants of degenerating adenomas were present in the center of the proliferating fibrous tissue. Whether or not this finding is of etiologic significance I do not know, but in most of the specimens in which the major portion of the affected lobe was removed, degenerating adenomas were found. In several cases it was impossible to judge whether the major portion of the lobe had been removed, as the operation had been accomplished by piecemeal technic and the specimen consisted of innumerable chips of fibrous tissue.

The microscopic picture is of a chronic inflammatory reaction and replacement of thyroid by fibrous tissue. Bulky tumors five or six times as large as the original lobe are formed in this manner and these tumors infiltrate the capsule of the thyroid, the trachea, the muscles, the tissues of the carotid sheath, and the recurrent laryngeal nerves, in such a way as to render it impossible to find any natural plane of cleavage outside of the capsule of the thyroid. The disease is in reality a diffuse fibrosis of the neck with the thyroid at its center.

From the histologic standpoint there is nothing specific by which Riedel's thyroiditis can be recognized, but the gross appearance of the lesion is unmistakable.

The entire lobe of the thyroid is stony hard, adherent, and avascular. It can be cut in any direction without bleeding except from an occasional vessel which can be seen protruding from the fibrous tissue. The blood supply has been choked off by fibrosis. The gland is brittle and white, and cuts almost like cartilage. The difference between Riedel's and subacute thyroiditis is in the degree of destruction of the thyroid epithelium, the relative scarcity of

foreign body giant cells, in the extent of the extracapsular fibrosis, in the size of the gland, and in the fact that in Riedel's there is apt to be a degenerating adenoma at the center of the process. The fibrous tissue seems to be laid down in layers around this adenoma to form concentric rings, like an onion.

Treatment An adequate trial of roentgen-ray therapy was made in three of these cases without significant results. In two cases in which one lobe had been removed and a recurrence later took place on the other side the roentgen-ray seemed to prevent further proliferations, although there was no change in the size of the tumor. In a third case, in spite of 2550 r of roentgen-ray, pain and symptoms of compression continued, hypothyroidism developed, and the

process extended to involve the parathyroids and produced tetany. We must assume, therefore, that roentgen-ray has little to offer in the treatment of this disease.

Complete surgical removal of the involved portion of the thyroid may be rendered utterly impossible by the extent of the extracapsular fibrosis. Serious damage to the trachea, carotid sheath, or recurrent nerves may take place if the true nature of the lesion is not recognized and radical extirpation is attempted. In this disease one must often be content to do the best he can within the bounds of safety to relieve obstruction.

On the other hand, if one remembers the fact that in most cases, at the center of the fibrosed lobe, there is a degenerating adenoma and that around this ade-



FIG 6—Case 3. Riedel's struma. The specimen represents only the portion of the lobe that was enucleated. Note adenoma encased in dense, concentrically laminated fibrous tissue.

noma the fibrous tissue is deposited in concentric laminations which afford natural cleavage planes, it is often possible, without jeopardizing the vital structures adherent to the capsule of the thyroid, to split the lobe open and enucleate this central core (Fig 6). The results following this simple procedure have been excellent in the three cases in which I have found it practicable. Pressure symptoms have been relieved, the bulk of the tumor has been strikingly diminished, and the progress of the inflammatory and productive process appears to be arrested. It is well to remember that the most severe obstruction to respiration usually is associated with retrotracheal adenomas that compress the trachea from behind and that this can be demonstrated before operation by a lateral roentgenogram of the trachea. If the surgeon is not aware of the retrotracheal tumor he is apt to overlook it in a thyroid which cannot be mobilized and rotated from its bed.

Six of the 11 patients who had portions of the thyroid removed for Riedel's struma are well. In seven patients only one lobe was removed, and in two of these the process recurred on the other side. One patient had bilat-

eral involvement and has a symptomless persistence of the disease after removal of part of one lobe. One patient has hypothyroidism, and one chronic tetany which developed spontaneously before operation, probably as a result of destruction of the parathyroids. The thyroid is so extensively destroyed that this patient also has hypothyroidism.

Case 3—The patient was a woman 46 years old. She had noticed an enlargement of the left lobe of the thyroid two years before entry, and a few months later she became

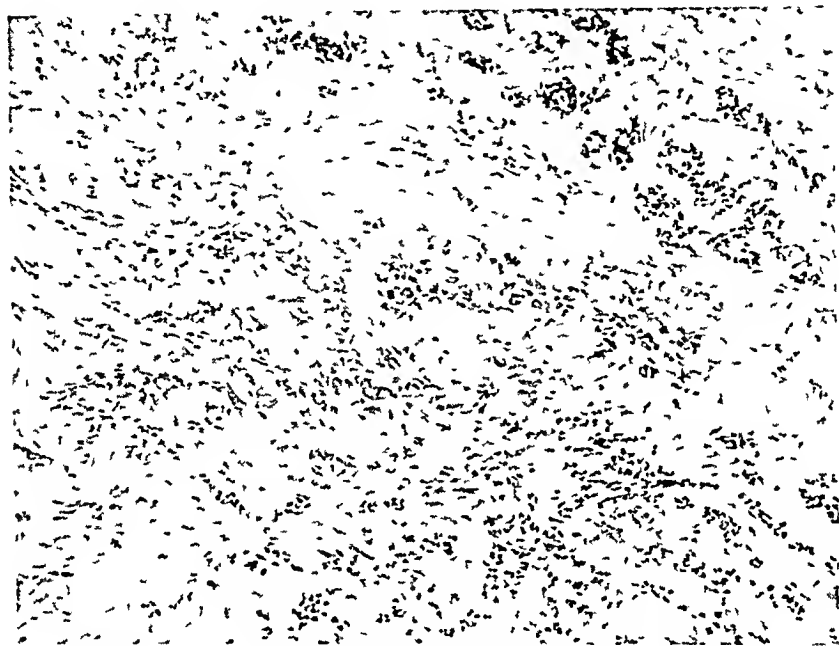


FIG 7—Case 3 Photomicrograph Riedel's struma ($\times 50$)

hoarse. Three months before entry an attempt was made to do a thyroidectomy, but the surgeon stated that the tumor was an inoperable carcinoma. A biopsy was interpreted as either Riedel's struma or carcinoma.

Symptoms of pressure continued, but there was no loss of weight and no symptoms of systemic disease.

Examination showed a stony hard, fixed tumor involving the left lobe of the thyroid and the cervical musculature. The left vocal cord was paralyzed. The basal metabolic rate was $+2$ per cent.

A diagnosis of Riedel's struma or inoperable carcinoma was made. At operation the entire left side of the neck was involved in a dense proliferation of fibrous tissue which had invaded the trachea and the prethyroid muscles. The lobe was exposed and the anterior half removed. It was white, brittle, and avascular. The cleavage plane surrounding the central adenoma was located, and a degenerating adenoma was shelled out in a capsule of fibrous tissue (Fig 6). The right lobe was normal.

The pathologist reported chronic inflammation and complete replacement of thyroid tissue with fibrous tissue (Fig 7). There was a degenerating colloid adenoma in the center of the fibrous mass.

Convalescence was uneventful and the symptoms of pressure were completely relieved.

Comment This case is typical of Riedel's struma in that (1) the initial diagnosis was carcinoma of the thyroid, (2) there was no systemic reaction or alteration of thyroid function, (3) there was extensive fibrosis of the thyroid and of the perithyroid structures, (4) there was a degenerating adenoma in the center of the fibrous mass, (5) symptoms were relieved by enucleation of the adenoma from the surrounding fibrous tissue

OTHER TYPES OF THYROIDITIS

During the same period of time in which these cases of specific thyroiditis were seen, there have been at least 10 cases of well-defined thyroiditis which do not fit into any definite category. There have also been three cases of suppurative thyroiditis occurring in degenerating adenomas. I have seen no proved syphilis or tuberculosis of the thyroid.

CONCLUSIONS

1 The clinical entity described as subacute thyroiditis has been proved by biopsy to be giant cell or pseudotuberculous thyroiditis.

2 Subacute thyroiditis, struma lymphomatosa, and Riedel's struma are separate clinical entities and probably are etiologically unrelated to one another, or at least do not represent various stages of the same disease.

3 The fact that subacute thyroiditis is almost always associated with pain and tenderness and that these symptoms only rarely occur in the other types argues against the possibility that subacute thyroiditis represents an early stage of the more chronic processes. The tendency to spontaneous recovery in subacute thyroiditis and its prompt and dramatic response to roentgen-ray treatment also argue against this possibility.

4 The fact that Riedel's struma is more often unilateral and struma lymphomatosa usually involves the entire thyroid,³ and the frequent presence of adenomas in Riedel's while they are rarely if ever recognized in struma lymphomatosa is further argument against progress of one lesion to the other. It is inconceivable that the fibrosis of Riedel's struma could regress and become a struma lymphomatosa.

5 Although the etiology of these diseases is unknown, it is possible that subacute thyroiditis is the result of a virus infection and that persistence of symptoms and evidence of inflammation in the thyroid is due to a foreign body reaction to colloid.

6 Struma lymphomatosa appears to be a systemic disease, possibly of the deficiency type, and further study of its relationship to achlorhydria, anemia, generalized lymphoid hyperplasia, and possibly to vitamin or other deficiencies is indicated. Many of these patients are not well before or after operation, and the hypometabolism and associated symptoms may not be specifically corrected by feeding desiccated thyroid.

7 Riedel's thyroiditis appears to be a proliferative fibrosis usually centering about a degenerating adenoma. Although the role of this adenoma cannot

THYROIDITIS

be proved, it is possible that some change in the adenoma sets off a fibrous tissue reaction resembling that seen in a keloid. Removal of the core containing the adenoma appears to promote subsidence of this reaction.

8 Roentgen-ray is the treatment of choice for subacute thyroiditis and thyroidectomy is rarely if ever indicated. Thiouracil may be of value.

9 In the rare cases of struma lymphomatosa in which the diagnosis is made before operation roentgen-ray should be given a trial. If struma lymphomatosa is recognized at the time of operation a very conservative resection of both lobes of the thyroid is recommended. The morbidity of radical resection is high and postoperative hypometabolism the rule when most of the gland is removed.

10 In Riedel's struma roentgen-ray is of little or no value, and surgery is apt to be difficult. It is unwise, unnecessary, and often dangerous to attempt to remove the entire lobe. If the onion-like concentric laminations in the fibrous tissue surrounding the central degenerating adenoma can be found, these avascular planes can be followed by blunt dissection and the core of the lobe shelled out without disturbing its capsule. Following this procedure the symptoms are relieved and there is no further proliferation of fibrous tissue.

NOTE: Since this article was prepared, 2 patients with struma lymphomatosa proved by biopsy have been treated by roentgen-ray. Fifteen hundred roentgen units was given. In 1 case the thyroid enlargement resolved promptly and was barely palpable at the end of three weeks. In the other the response was slower, but at the end of 6 months the thyroid was not palpable. In neither case was there improvement of the systemic symptoms.

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COARCTATION AND ANEURYSM OF THE AORTA

Report of a Case Treated by Excision and End-to-End Suture of Aorta

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IN 1944 ALEXANDER AND BYRON¹ reported a case in which an aneurysm of the descending aorta was treated by excision, with proximal and distal ligation of the aorta. This was the first recorded instance of resection of an aortic aneurysm. Their patient was a 19-year-old boy in whom a diagnosis of coarctation of the aorta was made, based upon the presence of hypertension in the upper extremities, weak arterial pulsations in the lower extremities, and well-developed collateral circulation evident during the operative dissection, and demonstrable by typical notching of the ribs on roentgenographic examination. Though the excised specimen did not include the area of stenosis the diagnosis of coarctation seemed well-established.

Studies in dogs in which an induced coarctation was treated by end-to-end anastomosis of the subclavian artery to the aorta below were reported by Blalock and Park in 1944.² In 1945 Gross and Hufnagel³ demonstrated experimentally the feasibility of excising a segment of aorta and repairing the defect by end-to-end suture. Shortly afterwards clinical cases of excision of the coarcted aorta with end-to-end repair were reported by Clafoord and Nylén⁴ and by Gross.⁵ Though only a few instances of surgical correction of coarctation have been reported thus far, the procedure is being utilized more frequently as time passes and with gratifying results.

The purpose of this report is to record an unusual case of coarctation of the aorta associated with an aneurysm distal to the stenosis treated successfully by excision and end-to-end repair of the aorta. So far as I am aware, there has been reported no similar instance of successful extirpation of an aortic aneurysm by excision and resuture of the divided aorta.

CASE REPORT

The patient was an 8½-year-old boy in whom a cardiac murmur had been detected at the age of 2 years. His mental and physical development had been normal but his general activity had been restricted because of the presence of the murmur. He had enjoyed good health up until the past year during which he had had several attacks of otitis media. On January 9, 1947, he developed an earache and a fever of 103.5°. Three days later he was admitted to the Bridgeport Hospital with a tentative diagnosis of rheumatic fever. On the day of admission, as well as on the 4th and 9th days after entry into the hospital, blood cultures were positive for pneumococcus Type VII. Salicylate therapy had been instituted upon admission and on the 4th day treatment with penicillin, 40,000 units every two hours, was begun. Because of the bacteremia, the cardiac murmur, and the continued septic fever, it was thought that he had bacterial endocarditis. On January 23 he was transferred to the Pediatric Service of the Grace-New Haven Community Hospital.

The patient was a well-developed, rather slender boy, with a temperature of 101° F and a pulse rate of 104. There was a loud blowing basal systolic murmur heard best to the left of the sternum in the first, second and third interspaces and also heard well posteriorly, especially to the left of the vertebral column. Some observers thought there might be a faint diastolic murmur though others could not hear it. Both tympanic membranes were dull but there was no aural discharge. General examination was not remarkable except for the murmur, the fever, and a brachial blood pressure of 140/70. The initial impression was that the patient had congenital heart disease and bacterial endocarditis. He was treated with penicillin 100,000 units every 2 hours and sulfadiazine 0.5 Gm every 4 hours. Blood cultures were negative and treatment was discontinued after 6 days. Roentgenograms of the chest showed notching of the ribs and questionable left ventricular enlargement. It was then noted that the pulses were weak or absent in the



FIG 1—Roentgenograms of the chest during barium swallow. The heart size is considered normal, it is perhaps slightly more globular in shape than is usually seen. On these and other films there is questionable evidence of slight left ventricular enlargement. Notching of the ribs is seen. A Preoperative roentgenogram. There is marked indentation upon the esophagus by the aneurysmal mass. B Roentgenogram taken on 12th postoperative day. The circular indentation of the esophagus seen in the preoperative film is not evident.

lower extremities. Some observers thought they could palpate a feeble femoral and popliteal pulsation, I could not feel them. The dorsal pedal and posterior tibial pulses were absent. It was apparent that the patient had coarctation of the aorta. Though there was a possibility that the bacteremia had resulted from aural infection, it was felt that it might well have originated from bacterial aortitis. The patient was discharged on February 3.

On February 20 he was re-admitted. He had remained well. The systolic murmur was again noted. The right brachial blood pressure was 150/104, the left 154/104. The femoral and popliteal pulses were absent or very feeble. The dorsal pedal and posterior tibial pulses were absent. Venous pressure in the left arm at heart level was 105 millimeters of water. Macasol circulation time from arm to tongue was 12 seconds, to the body 17 seconds, and to the right foot 25 seconds. The urine was normal, the erythrocyte count 4.6 million, the hemoglobin 12.5 Gm, the leucocyte count 7,400. Hematocrit was 39 and sedimentation rate 14 millimeters in 30 minutes. Plasma proteins were 7.3 Gm per cent and chlorides 103.8 milli-equivalents. The oral temperature ranged from 98.6° to 100.6° F. Electrocardiograms revealed evidence of a slight left axis deviation. Roentgenograms showed a left aortic arch. Though the diagnosis was not made before oper-

ANEURYSM OF AORTA

ation, in retrospect the roentgenograms with barium swallow (Fig 1A) revealed evidence of a mass in the region of the first part of the descending aorta suggestive of an aneurysm

On February 24, operation was carried out under intratracheal ether-oxygen anesthesia. A curved incision was made posterior to and below the left scapula. Numerous large collateral vessels were encountered in the subcutaneous and muscle layers. The fifth rib was resected subperiosteally from the transverse process out to the axillary line and a short posterior segment of both the 3rd and 4th ribs was excised. The aortic arch appeared to be somewhat smaller than normal. There was moderate dilatation of the left common carotid and marked dilatation of the left subclavian artery. The latter was about 1.3 cm in diameter at its base, about the same size as the arch of the aorta. Just a few millimeters beyond the origin of the subclavian artery there was a marked narrowing of the aorta (Fig 2). Beyond this point the thoracic aorta was a little more than

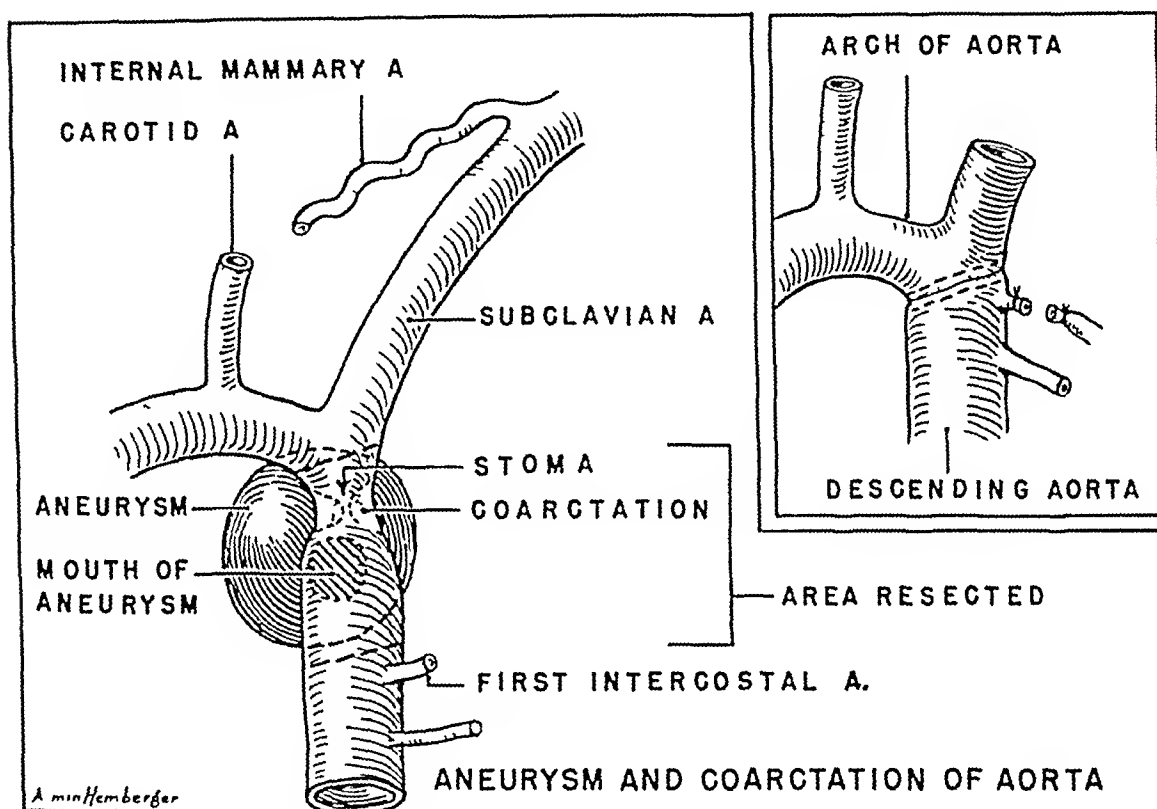


FIG 2—Diagrammatic sketch of the condition found at operation. The condition following excision of the aneurysm and coarcted portion of the aorta is shown in the insert.

2 cm in diameter. Here a marked systolic thrill was felt but there was no visible or palpable pulsation. The arch of the aorta and the vessels arising from it pulsated vigorously. The first left intercostal artery was markedly dilated and tortuous, the second slightly less enlarged and the third only a little larger than normal. The internal mammary artery was tortuous and much enlarged, being about 6 mm in diameter.

The first and second left intercostal arteries were dissected free in their proximal portions and, since it appeared essential for proper mobilization of the aorta distal to the coarctation, the first was divided between ligatures. Next the ligamentum arteriosum was isolated and divided between ligatures, it appeared to be obliterated. It was apparent that the coarctation existed in the area of the aorta connected with the ligamentum arteriosum. Dissection here and along the mesial and posterior aspects of the aorta was very difficult and tedious because of the presence of an aneurysmal mass almost twice the diameter of the aorta itself. It appeared to rise just below the coarctation and protruded against the esophagus mesially. The aneurysm was carefully freed except for the most



FIG 3—Low power photomicrographs of section through aorta and aneurysm Verhoeff elastic stain The proximal aorta is seen below Distal to the coarctation the wall of the aorta opposite the aneurysm appears normal but the aneurysmal wall has very little elastic tissue except for the knotted fibers on the ridge seen to the left of the edge of the mouth of the sac



PLATE 1 Kodachrome photographs of the excised specimen (A) The proximal end of the excised segment of aorta with the small aperture through the stenotic area and the aneurysmal sac below (B) The distal end of the excised aorta The opening from the aorta into the aneurysm is seen The black silk ligature is on the stump of the ligamentum arteriosum (C) The aorta and sac opened The small beady protrusions within sac wall suggest vegetations

mesial portion which I felt could not be separated safely from the esophagus and adjacent tissues until the aorta was clamped. The first and second right intercostal arteries had to be ligated and divided in order to mobilize the aorta properly. The subclavian artery and the distal end of the arch were mobilized. Special aorta clamps were now applied above and below the coarctation and the aneurysmal mass. In order to prevent occlusion of the subclavian artery the clamp was placed tangentially across its origin and even so a rather short segment remained between the clamp and the stenotic portion of the aorta. With the clamps in place the sac was now completely freed without rupture. About 25 to 30 cm of the aorta were excised, including the area of coarctation and the aneurysm. The two ends of the aorta were approximated with a continuous everting mattress suture of number 5 Deksnel, interrupted in several places. Since the proximal aorta was smaller than the distal, it had been sectioned tangentially in order to make its divided end more nearly the size of that of the distal segment. The clamps were released slowly with the patient in Trendelenburg position and during rapid intravenous administration of blood. No significant fall in blood pressure occurred. Two small leaks on the posterior wall at the line of repair were stopped by additional sutures, the area was now dry. The distal aorta pulsated vigorously. The mediastinal pleura was approximated with interrupted silk sutures and, following, inflation of the lungs, the wound was closed in layers with silk sutures.

The stoma through the stenotic portion of the aorta had a diameter of only 15 mm (Plate I). Just distal to the coarctation on the posteromesial aspect was an opening about 1 cm in diameter into an aneurysmal sac of about twice the diameter of the aorta itself. Within the sac were present small pearly protrusions which looked very much like vegetations. The aorta showed no significant microscopic changes except in the area of stenosis and in the region of the aneurysm (Fig 3). The fibro-elastic media appeared well preserved. At the site of the coarctation the subendothelial fibrous connective tissue was reduplicated, there was a thick layer of dense scar tissue, and the fibro-elastic media was largely replaced by fibrous connective tissue which extended in strands into the proximal and distal aorta. Here the laminations were distorted with separation of the fibrils by an increased amount of fibrous connective tissue. Opposite the mouth of the aneurysm the media of the aorta was normal in appearance. At the opening of the aneurysm the elastic tissue ended abruptly and the elastic fibers were coiled into knotted and entangled fragments. The sac itself was composed of dense collagen fibers, forming a connective tissue wall which was infiltrated with many plasma and mononuclear cells especially about the blood vessels. There were rare scattered thin atrophic elastic fibers here and there in the wall of the aneurysm, otherwise no elastic tissue was present except in the region of a fold upon which the vegetation-like lesions were centered. Here there was a dense mass of knotted elastic tissue fibers external to which an area of necrosis with numerous polymorphonuclear leucocytes was seen in the wall of the sac, and internal to which was dense fibrous connective tissue. The entire sac was lined with a thin layer of blood platelets and fibrin. Bacterial stains demonstrated no organisms. The blood vessels in the wall of the sac showed occlusion of the lumen by proliferation of endothelial cells, connective tissue replacement of the musculature, and fragmentation of elastic tissue.

The patient had an uneventful convalescence. Vigorous femoral, popliteal, dorsal pedal and posterior tibial pulses were present immediately after operation and popliteal blood pressure was 124/90. The following day blood pressure in the thigh by auscultation of the popliteal vessels was 140/100, blood pressure in the arm 112/90. Twenty-thousand units of penicillin were administered every 3 hours for 10 days. Except for an elevation to 101° on two occasions, the temperature was never over 100° and soon became normal. The patient was kept in an oxygen tent during the first day and night. He was allowed up in a chair on the 4th day and began to walk on the 8th day. His urine and blood count were normal. On occasions a faint precordial systolic murmur was

present, although it was sometimes inaudible. Roentgenograms with barium swallow showed an absence of the mass previously demonstrated (Fig 1B). The patient was discharged on February 10 and was allowed to be normally active. On discharge blood pressure in the right arm was 118/86, left arm 112/90, right thigh 134/90, left thigh 130/94. Oscillometric studies revealed normal values, 5.5 to 6 in the thighs, 3 to 4 in the legs. The patient remained well.

He was re-examined on April 26. He had gained 10 pounds during the past 2 months. Heart rate was 75. There was a short systolic murmur heard to the left of the sternum centered about the 4th interspace. Blood pressure was 106/70 in the right arm, 102/70 in the left arm, 108/70 in the right thigh, 104/70 in the left thigh. Femoral, popliteal and posterior tibial pulses were full and equal. Oscillometric studies again showed normal values, 5.5 and 6 in the thighs, 4.5 and 5 in the legs, and 1.2 and 1.4 in the ankles.

DISCUSSION

Several interesting problems are presented in connection with the case reported. The first deals with the coexistence of coarctation and aneurysm of the aorta and of coarctation and bacterial aortitis. As Abbott⁶ pointed out in her review of 200 cases verified at postmortem examination, dilatation of the ascending aorta is very common. This was the finding in 101 cases, while in 7 the aorta was normal in size, and in 21 hypoplastic. No comment concerning this matter was found in the records of 71 cases. She observed that the state of dilatation varied greatly from case to case and that in some a diffuse or saccular aneurysm resulted, or a dissecting aneurysm which, in turn, sometimes ruptured into adjacent structures. She gave no data concerning the incidence of expansion of the descending aorta but remarked that "localized dilatation of the descending thoracic aorta *immediately below* the stenosis is common." The enlargement of the descending aorta is often a bulbous dilatation with a normal sized aorta below the 4th or 5th intercostal. In her survey, 7 examples of saccular or spindle-shaped aneurysm distal to the site of coarctation were mentioned, in three of them rupture with fatal hemorrhage ensued. Nine instances of mycotic aneurysm beyond the coarctation were mentioned in three of which rupture occurred.

The recent review of 104 additional autopsied cases of coarctation by Reifenstein, Levine and Gross⁷ records no specific data concerning the incidence of aneurysms. They stated, however, that dilatation of the aorta was commonly observed in the ascending and, less commonly, in the descending portion. It is of interest that the incidence of rupture of the aorta as a cause of death in their cases was nearly the same as in Abbott's series (23.1 per cent as compared with 20 per cent) and that bacterial endocarditis or aortitis caused more deaths in their series than in Abbott's (22.1 per cent as compared with 16 per cent).

Rupture of the aorta apparently bears a direct relationship to aortic dilatation or disease. Abbott noted death from rupture of the ascending aorta in 33 cases and at or near the site of coarctation in five cases. Referring to the 33 cases of rupture of the ascending aorta she pointed out that the aorta was markedly dilated in 29 and frequently was the site of an aneurysm, in the

great majority a dissecting aneurysm had formed with subsequent rupture. Reifenshtein *et al* observed rupture of the ascending aorta in 19 cases and of the descending aorta in five. Among 14 cases of mycotic endarteritis in Abbott's series the infection was at the seat of coarctation in 13, while one was a mycotic aneurysm of the ascending aorta. Nine of the cases of endarteritis in the region of the coarctation had mycotic aneurysms. Similarly Reifenshtein and his associates observed six deaths from bacterial aortitis, which in two cases affected the ascending aorta and in four the aorta distal to the coarctation. Their survey included one case of spontaneous recovery from bacterial aortitis followed by progressive aneurysmal dilatation and calcification of the affected portion of the aorta, possibly mycotic in origin. They also mentioned another case in which an alpha streptococcal bacteremia was presumably cured by penicillin therapy with subsequent aortic dilatation distal to the coarctation. It is well-known that limited rupture of a vessel with production of a non-fatal dissecting aneurysm may result eventually in a lesion indistinguishable from any other saccular aneurysm. Their report included one case of a dissecting aneurysm distal to a moderate coarctation which showed at postmortem examination 19 months later an "endothelialized" lumen.

Several factors may contribute to the dilatation of the aorta and to the formation of an aneurysm or rupture. With regard to the ascending aorta the question of hypertension and the relative increase in intra-aortic tension due to stenosis at the seat of coarctation must be considered. Gross and microscopic evidence of alterations in the wall of the aorta have been observed. Though Reifenshtein and his co-workers deplored the infrequency with which case reports included careful microscopic studies of the aorta at the site of rupture and below and above the coarctation, they pointed out that decrease in the thickness of the media was generally noted, with necrosis, hyaline degeneration, fibrosis, decrease in and fragmentation of the elastic tissue, and cystic change. They also pointed out that atheromatosis was common, that the vasa vasorum were occasionally narrowed, and that the outstanding alteration was destruction of elastic tissue. The relative roles of hypertension and of congenital changes of the aortic wall in the production of these lesions is not well-established. Abbott spoke of several factors which may influence the development of an aneurysm distal to the coarctation. She stated that the bulbous dilatation just beyond the coarctation was a "direct result of the return of the collateral circulation through the aortic intercostals." She also pointed out that "even where this localized increase in diameter is not marked, the aorta just below the constriction at the entrance of the collateral blood often shows a patchy atheroma, which may act as a predisposing factor for the formation of a dissecting aneurysm with spontaneous rupture in this situation or for the development of a mycotic aneurysm." In addition she stated that in other cases traction by the ligamentum arteriosum produces a kinking or outpouching of the right lateral wall of the aorta, and that this area may rupture externally.

In my case the aneurysm was not recognized before operation. The patient had no complaints attributable to such a lesion and ordinary chest roentgenograms revealed no mass suggesting an aneurysm. Roentgenograms taken during barium swallow, however, showed a large esophageal indentation which was hardly compatible with the usual impression made by the aortic knob. The laminograms demonstrated a mass near the tracheal bifurcation which was absent after operation and which was much the same in size, shape and position as the aneurysmal mass. It was evident in retrospect that these observations should have established the diagnosis before operation.* Examination of the excised specimen gave no specific clue as to the etiology of the lesion. It was similar in gross and microscopic appearance to the usual saccular aneurysm produced by disease of the arterial wall or by trauma and to the ordinary mycotic aneurysm after subsidence of infection. There was no bulbous dilatation of the first part of the descending aorta, so that general thinning of the wall from such a process is not a likely explanation for the production of the lesion. It was situated on the right lateral wall of the aorta but since the ligamentum arteriosum was attached several millimeters proximally at the site of the stenosis, it appears unlikely that traction by this structure was a factor. The mouth of the sac was in an area where atheromatous plaques are common and it is entirely possible that the giving way of such a lesion may have produced the aneurysm. The patient had a pneumococcal septicemia and the sac was lined with an irregular organized thrombus which grossly resembled a vegetative process. Though no organisms were demonstrable, the microscopic picture was not incompatible with an infected vegetation which had been rendered sterile by penicillin. Whether the bacteremia resulted from such a process or from the mild otitis media cannot be established. It seems unlikely that a bacterial aortitis at the time of the bacteremia could have produced a mycotic aneurysm which would have such a well-organized gross and microscopic appearance 7 weeks later. It is entirely possible, of course, that the lesion may have developed asymptotically as a mycotic aneurysm some time in the past.

The second problem raised by the case reported concerns the treatment of aneurysms of the aorta in general and in particular those of the descending thoracic aorta. Bigger,⁹ Elkin,¹⁰ Alexander and Byron, and de Takats and Reynolds¹¹ have recently reviewed the literature concerning the operative treatment of aneurysms of the aorta and have pointed out how few are the cases of successful results from ligation. As far as I can ascertain only in the case of Alexander and Byron and in the case which I have described has an aortic aneurysm been excised, and only in the latter case has the aorta been repaired by end-to-end suture. Attention should be called to the fact that

* Clark and Koenig⁸ have recently reported a case of saccular aneurysm distal to the area of coarctation proved at autopsy which was recognizable on roentgenographic examination because of calcification of the sac wall. They presented a second probable case of distal aneurysm in which a shadow was visible on ordinary films of the chest.

recently two cases of arteriovenous fistula of the abdominal aorta have been treated successfully by closure of the arterial defect with maintenance of the continuity of the aorta^{12, 13} In general it has been necessary to treat aortic aneurysms by some method such as internal wiring and coagulation Some excellent results have been obtained with this method^{14, 15} and I have been reasonably well satisfied with most of the cases which I have treated in this manner Unless this procedure can be combined with complete aortic occlusion, however, it must be looked upon as a palliative rather than a curative measure

In speculating upon the feasibility of excision of aortic aneurysms the problem of collateral circulation immediately comes to mind, and it is of interest that the only two cases thus far so treated have been instances of aneurysm in conjunction with coarctation It would, of course, be possible to excise an aneurysm and ligate the severed aorta only if well-developed collateral circulation were present Even then one would be concerned with the production of hypertension unless the ligation were carried out in the distal aorta Indeed, without adequate collateral circulation one might be fearful of occluding the aorta temporarily in cases in which it appeared likely that restoration of continuity of the aorta might be accomplished, because of the hazard of ischemic damage to the spinal cord, a complication often noted after temporary aortal occlusion in dogs Only further experience will reveal whether the aorta can be safely occluded temporarily in the absence of abundant collateral circulation and for how long To be sure, Crafoord has often clamped the aorta in cases of patent ductus arteriosus during closure of the aortic end of the ductus without harmful effect He informs me that up to June 1947 he has thus completely occluded the aorta for intervals of from 12 to 28 minutes in 31 patients without difficulty, only in one instance in which the occlusion was maintained for 48 minutes did symptoms of spinal cord injury follow

The problem of bringing about development of adequate collateral circulation around a segment of aorta has been discouraging due to the tendency of external bands and ligatures to cut through the wall of the vessel in time, with resultant fatal hemorrhage Blakemore has, however, recently made an important contribution in demonstrating that the diameter of the aorta can be safely narrowed by progressively decreasing its lumen with coils of fine wire introduced within it From his experience it would appear that a safe and reliable method is at hand for producing partial occlusion and for aiding the development of collateral circulation

If then, methods are available for increasing collateral circulation or if it becomes evident that the aorta can be safely occluded temporarily without obviously increased collateral circulation, one is justified in speculating further upon the possibility of excising aortic aneurysms Should excision be possible there can be no question that one should aim ideally towards restoring blood flow through the aorta in order to prevent hypertension in cases of proximal aortic lesions and in order to circumvent intermittent claudication and other ischemic difficulties of the extremities It is unlikely

that one could so mobilize the aorta as to permit end-to-end suture in any cases other than those of excision of a relatively short segment of the proximal portion of the descending aorta. It must be emphasized that the adult aorta is less pliable and less easily mobilized than that of the child and that rigidity and fixation of the aorta are especially prominent in cases of arterial disease. In general it would be necessary to insert a venous transplant into the defect. Experiences with vein transplantation in peripheral arteries¹⁶ lead me to believe that vein grafts to bridge aortal defects may be feasible. It is unlikely that excision of aneurysms of the ascending aorta, the arch, or the first part of the abdominal aorta which gives rise to the important nutritive branches supplying the abdominal viscera will ever be possible. I do think, however, that it is within the realm of possibility that some day aneurysms of the descending thoracic aorta and of the distal abdominal aorta may be treated successfully by excision and restoration of continuity of the aorta. Experiments are being undertaken to test further these possibilities.

SUMMARY

A case is presented of coarctation of the aorta complicated by a saccular aneurysm distal to the coarctation and by bacteremia which may possibly have resulted from infected vegetations within the sac. The bacteremia was treated successfully by penicillin and sulfadiazine therapy and the coarctation and aneurysm were subsequently excised with repair of the aorta by end-to-end suture.

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THE CHANGING SCENE IN AMERICAN SURGERY*

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I AM HONORED to have been asked to give the John Chalmers Da Costa Oration. Doctor Da Costa was the first surgeon whom I met after coming to Philadelphia in 1916. I had been given a letter of introduction to him when I came East. A few days after I arrived in Philadelphia I had dinner with Doctor Da Costa at the old University Club on Walnut Street. On numerous occasions thereafter I attended his famous Wednesday afternoon clinics to which came not only students from his own school but also many from my alma mater across the Schuylkill. He was the most accomplished medical lecturer I have known. His knowledge of the history of medicine and surgery, and of current surgical literature, coupled with a rarely equalled vocabulary and form in exposition, made him a most fascinating speaker. I wonder how many of the young men in medicine and surgery have read his collected essays in "The Trials and Triumphs of the Surgeon." They might well be made required reading for medical students. He was a worthy successor to the men who so ably have filled the chairs of surgery at the Jefferson Medical College, and he occupied the Samuel D. Gross Professorship from 1910 to 1930.

Those who have read his essays know that he frequently wrote on the surgery of the past but rarely gave way to speculation on the future of the profession he so dearly loved. It was with some misgiving that I chose as my subject "The Changing Scene in American Surgery." Although we might not have agreed upon what the future has in store for us, we would, I am sure, have agreed upon an evaluation of the surgery of the past. The historian who has before him facts upon which to base his assertions is much more likely to be correct than is the crystal gazer who, with a limited knowledge of the past, attempts to be prophetic of the future.

I propose, therefore, rapidly to pass in review some of the major historical epochs in surgery before attempting to evaluate the present and future trends in surgery. It may stand us in good stead, for we are too apt to forget our debt to those who have gone before us, and it is difficult at times to reach a proper perspective of the importance of present tendencies, without some knowledge of the past.

Hippocrates, who was born in 460 B C, can well be called the Father of Surgery, although in his lifetime all the branches of medicine were carried on by the single practitioner. He provided an excellent discussion of the lighting of an operation room and the care of the surgeon's hands. He detailed carefully and minutely how the surgeon should work. He laid the foundation for

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cerebral localization, and his observations on cerebral trauma were excellent, even in the light of our present knowledge. His discussion of wounds and their treatment can be read with profit today, and his writings on fractures and dislocations were unique for nearly 1,500 years. He was the father of inductive research in medicine and he laid the foundations of physiology.

Galen, who was born nearly 600 years later, was the father of deductive research in medicine. He discovered the cranial nerves and the sympathetic nervous system and described the method by which urine flowed from the kidneys to the bladder. Yet, in spite of his keen power of observation, he frequently gave vent to riotous speculation. Charles Burr, in speaking of Galen, once said, "It was not his fault that for centuries the world accepted all his hypotheses as final," for the authority of Galen, often erroneous, persisted for nearly 1,500 years.

Vesalius, Eustachius, Fallopius and Fabricius were perhaps the four greatest anatomists of the Renaissance. These men more than any others placed morphologic anatomy on a sound basis. How tawdry are the anatomic illustrations in modern textbooks when compared to those of the great Italian School of the Renaissance.

Fabricius was the teacher and preceptor of William Harvey. He had long been interested in the vascular system and to him belongs the credit for having fired Harvey's imagination, for Fabricius had recognized the existence of valves in the veins and had noted that they were all turned toward the heart. Harvey's experiments were begun in the year of the death of William Shakespeare. A great discovery is rarely, if ever, the sole achievement of one man. Many had stood on the threshold of the discovery which Harvey finally made. Galen, in fact, had once written, "If you would kill an animal by cutting through a number of its large arteries you will find the veins becoming empty along with the arteries, now this could never occur if there were not anastomoses between them." Harvey's great work, which he wrote of in his immortal "*De Mortu Cordis*" was due to his use of sound experimental methods. But even Harvey did not know of the paths by which the arterial and venous systems communicate, and his discovery was not made complete until Malpighi in 1661 demonstrated by the use of microscope the existence of capillaries.

The experimental method, which was utilized sporadically, found no lasting place in surgery. The art of surgery was being practiced with a somewhat wider scope, but very few significant advances were made. Surgeons still accepted Galen's dogma that suppuration was an essential part of wound healing, they were not as yet convinced that all pus was evil.

It was not long after the time of Hippocrates that surgery became looked upon as a menial task involving simple craftsmanship. The capacity to do an operation successfully depended upon the qualities of an individual, not upon training common to all surgeons. The social and scientific standing of the "barber surgeons," who inherited this menial aspect of medicine, left much to be desired, but from this group came Richard Wiseman and Ambroise Paré.

Both were astute observers and skillful operators, and Pare, who at the age of twelve decided to become a surgeon, must always be considered as one of the greatest surgeons of all time

John Hunter in the latter part of the eighteenth century, gave surgery the beginning of a sound foundation in pathologic anatomy. Hunter was an observer and investigator, and he was responsible for changing the spirit of surgical practice. The museum which he founded in the Royal College of Surgeons in London was the mecca of surgeons of the English speaking world until the ruthless Nazi raids on London destroyed it.

It was not until 1805 that the School of Medicine of the University of Pennsylvania deemed it expedient to separate the Chair of Surgery from that of Anatomy and Obstetrics, at which time Philip Syng Physick was appointed to the first Professorship in Surgery. Even in Edinburgh there was still a combined Chair of Surgery and Anatomy. When Physick was appointed, pain, hemorrhage and infection still impeded surgical progress. It is true that in 1799 Humphrey Davy, who had not then gained renown as a physicist, had written, "Since nitrous oxide is capable of annulling pain it might be used in surgical operations in which there is no great effusion of blood."

Can you for a moment picture the agony which was endured in the days before the introduction of general anesthesia? Hayden has given us this picture in his classic description when he says, "With a meek, imploring look and the startled air of a fawn, she is laid on the table and in spite of opiates previously administered, agonizing screams burst from her at the first cut of the scalpel. Strong men are at hand to pinion her down until the operation is completed. At length it is finished, and prostrate with pain, weak from her exertions, and bruised by the violence used, she is borne from the amphitheatre to her bed in the wards to recover from the shock by slow degrees." Such was the horror of operation in the days before Long and Morton gave to the world contributions for which we must remain eternally in their debt. Were it not for them the practice of medicine and surgery might still be little changed from that of the dark ages.

Paré had used ligatures extensively for the control of hemorrhage and Physick had experimented with the use of absorbable sutures and ligatures. By the middle of the 19th century Valentine Mott of New York had tied more large blood vessels than any other surgeon living or dead. The importance of hemostasis and methods for the control of hemorrhage became better understood.

While Physick was practicing in Philadelphia, the "living pathology" of the abdomen began to be written in Kentucky. There in what was then called the "Far West" in December, 1809, Ephraim McDowell, a pupil of Hunter, successfully performed the first ovariectomy. Thirteen years later William Beaumont, an army surgeon stationed at Michillamackinac, Michigan Territory, was called to treat Alexis St. Martin, who had been accidentally wounded by the discharge of a shot gun. St. Martin had sustained an injury of the chest wall, the left lung and diaphragm and the stomach. A year passed and Beau-

mont reported that "The injured parts were all sound and firmly cicatrized with the exception of the aperture in the stomach and the side"

Beaumont is generally regarded as the first American physiologist, but he was by act and inclination a surgeon. He was not appalled by the handicaps in knowledge which were arrayed against him. He utilized his unique patient to make lasting contributions to our knowledge of normal gastric function.

Then came the War Between the States and the best efforts of surgeons were still frustrated by infection. Of 3,117 gun shot wounds of the abdomen treated in army hospitals in the Civil War only 444 recovered, a mortality of 85.8 percent, while during World War II of those admitted to hospitals with abdominal wounds nearly 80 per cent recovered. It was not until 1881 that Kinlock of Charleston performed the first abdominal section for gunshot wound of the intestines. Those who recovered from abdominal injury in the Civil War either did not have perforation of the intestines or recovered following the formation of an abscess. It remained for Joseph Lister in 1865 to apply Pasteur's researches on fermentation to clinical surgery and to prove once and for all time that all pus is evil, that healing by primary intention, of which Paré had written more than 200 years before, could be attained.

The die was cast for a rapid expansion of surgical effort. Operations which previously could not be attempted, or, when they were, had a prohibitive mortality, began to be done not by a single surgical adventurer or genius, but by many surgeons. They were soon being done with a degree of safety that belied Baron Boyer's statement in the early nineteenth century that surgery had reached the greatest heights to which it could ever attain. The time was now ripe for a surgical approach to many hitherto unattacked lesions of the abdominal and other viscera. Many were the men who were spurred on to operate for lesions of the stomach, the gallbladder, the small and large bowel and the pelvic viscera. In Doctor Da Costa's School the names of W. W. Keen, the elder Gross, and Pancoast, and in my own Agnew, John Ashhurst and Deaver stand out in the galaxy of American surgeons who in the latter part of the last century exerted a powerful influence in the new revolution in technical surgery.

Toward the end of the nineteenth century a very great change began to take place in our medical schools. They were no longer institutes of anatomy and pathology to which were attached the clinical departments of medicine, surgery and obstetrics. Bacteriology, physiology and physiologic chemistry became independent fields of scientific effort and training. They assumed an ever increasing portion of the time of the medical student, and they played an ever increasing role in the progress of surgery.

Antiseptic surgery gave way to aseptic surgery in spite of those who believed that the older system was sufficiently good. New anesthetics began to be available to surgeons and poor methods of anesthesia gave way to better methods. Operations designed merely to alleviate temporarily the symptoms caused by certain diseases gave way to more radical and to more physiologic procedures designed to cure these disorders.

The great Billroth had issued his dictum, "Das innere medicin must mehr and mehr chirurgisch bekommen" Surgeons, following their colleagues in internal medicine, began to utilize the expanding knowledge of normal function which was made available by those working in the fundamental medical sciences, and they in turn as a result of operation in the early stages of certain diseases made available the knowledge of the abnormalities from normal function which were brought about by early disease. Prior to this time symptoms were correlated all too frequently with the findings at the autopsy table. The pathologic physiology of early disease of many viscera was poorly understood.

This was the period of the great individualists in surgery. Many of them became known throughout the world, but few of them recognized their responsibilities to their communities and to medicine, for few of them really trained many young men. The young man interested in a career in surgery still had to make his rent and board in general practice.

Progress in any art or science nearly always is dependent upon the training of the men who devote their lives to study in any special field. Surgeons in general were still trained by periods of semipreceptorship, or they were self-trained until William Halsted had the vision that such training was inadequate. As the result of his genius the resident system in surgery was born. He taught his proteges the importance of carefully studying their patients, of attempting to improve their condition prior to operation, of good anesthesia and of the gentle handling of tissues. He surrounded them during their years of training with the spirit of investigation and he encouraged them to be investigators. He forged a new method of graduate surgical training which provided increasing responsibilities and opportunities. He more than anyone else in our lifetime made surgeons realize that an operation was not successful unless the patient became well again.

In his essay on "The Trials and Triumphs of the Surgeon" Doctor Da Costa said, "It is the solemn and imperative duty of a surgeon to give able and worthy young men a chance to become surgeons. He should train them—weed out the unfit—stimulate and encourage the fit—stand by them till they can go it alone. I venture to say that Professor Halsted is as proud of nothing in his distinguished career as of that splendid group of brilliant men he trained and started on the road to eminence. A surgeon who deliberately fails to train young men is guilty of a crime against humanity. A hospital management which makes a surgeon fail in this duty is criminal."

Halsted constantly stressed the fact that the ultimate aim of surgery was to restore function. He realized that to do this the surgeon must have an intimate knowledge of normal function, which is physiology, and to this his direct and indirect disciples have added physiologic chemistry and the allied basic sciences.

Such knowledge has made possible the great advance in preoperative preparation and postoperative care of our patients, achievements of the greatest importance during the past 20 or 25 years, and in the main brought about by American surgeons. Fluid and electrolyte balance, shock and its therapy,

visceral protection against noxious agents, intestinal intubation, factors influencing wound healing and many other fields have been intensively studied, and these studies have led to advances which have added immeasurably to the safety of patients who must undergo anesthetization and operation. The surgical residents, the internes and even the medical students now realize, although the lay group may not, that pre- and postoperative care is as important to the surgical patient's welfare as is the operation, and that when such care is thoughtlessly or carelessly given, it may be as catastrophic as carelessness in operative technic.

The old argument regarding the efficacy of heat or cold when applied to the abdomen of the patient with peritonitis is rarely heard today, for it is now known that neither heat nor cold applied to the abdominal wall can in any way influence the course of the infectious process. The traditional order "push fluids" of the midtwenties has been supplanted by careful orders designed to provide the individual patient with the fluid, electrolytes and other substances which that particular patient requires. It took World War II to make us realize that there is no such thing as a "blood substitute" although new and useful materials for restoring plasma volume have been found.

As the etiology of many diseases became more clearly established and the methods for cure more definitely defined there began to develop an ever-increasing group of surgical specialties. It soon became evident that patients who needed surgical care had the best chance of getting well when treated by surgeons who had been specially trained in a specific field of surgery.

The advances in surgery during the past few decades have not been concerned alone with pre- and postoperative care. The expanding knowledge of physiologic function has stimulated major extensions in technical surgery. Cushing, as a result of his knowledge of neuropathology and neurophysiology, was able to develop a specialty of the field of neurosurgery and to make it a relatively safe one. Recent additions to pulmonary, cardiac and vascular surgery have been possible because of an intimate knowledge of normal physiologic function, and the surgery of these systems has a rational and sound foundation. The surgeons who have explored, and are continuing to expand these fields could not have attained the brilliant results which they have, however great their technical skill, had they not been able to utilize the fundamental knowledge which investigators in the basic sciences have made available.

The application by surgeons of basic research to the practical problems presented by patients is frequently in the headlines, while the painstaking efforts of an imaginative scientist who made the fundamental observation is all too frequently overlooked by clinician and layman alike. Applied research is important and valuable, but it is impossible without pure research. It is an unfortunate circumstance that the importance of the latter is still too often belittled by those who do not understand its relation to the whole field of clinical medicine.

Most of the men who have contributed to the modern expansion of sur-

gical effort have been relatively young men. William Mayo in speaking of them said, "Youth without experience attacks unsolved problems which maturer age with experience avoids, and from the labors of youth comes progress." Imbued with the spirit of investigation they have perfected new methods of therapy, discovered the explanation of various clinical phenomena, improved pre- and postoperative care, and added to our knowledge of normal and pathologic physiology. They have been responsible in large part for bringing the art and science of surgery together.

The time has now come when we must take stock and determine, if we can, the direction in which surgery and surgical training shall take in the future. We have a great advantage over our predecessors, even over Doctor Da Costa, for we have had a longer period to see the benefits which come from the superior scientific training which our medical students and graduates in training are receiving. We can now be sure that there can be no substitute for planned resident training in surgery or the surgical specialties, wherein the trainee is provided with increasing opportunities for work and development, and given more and more responsibility as he demonstrates his ability.

I do not believe there is any problem in training an operator. Given a young man with dexterity it is a small accomplishment to train him to become skillful in even complicated technics. The laboratory diener who surpasses most of the students and even teachers in placing sutures is not uncommon. The young graduate who is selected for surgical training is chosen for his knowledge of science, for his broad interest in medicine, and for his ability to carry theory into practice, as well as for his manual skill. If he then receives his training in a clinic where the spirit of investigation is constantly present, where the study of the patient is made with the same thoroughness that it is made in a medical ward, he should certainly develop into a better surgeon than will the graduate who receives his training in an atmosphere of semi-empiricism and emphasis on minor technical achievements. The operator may have many brilliant operations, but the surgeon will have many well patients.

We must consolidate the experience of the past three decades in surgery and strengthen surgery below the level of specialization. I am not unmindful of all that has been done for American surgery by the American College of Surgeons and by the various academies of the surgical specialties. I am not unmindful of the benefits that have resulted from the efforts of the American Board of Surgery and the various specialty boards, but I would be remiss in my duty were I to fail to point out that a sound foundation in general surgery is the best training for any surgical specialist.

The first generation of surgical specialists was almost universally made up of general surgeons who developed particular interests in special fields and devoted more and more of their time to these fields, finally becoming known for their accomplishments in their specialties. Each of these men had his disciples whom he trained in his field, but with his own background he was able to give them of his own experience in general surgical principles.

More recently the intern has gone at once into specialized training which is too often directed by a specialist with no first-hand knowledge of general surgery. We must, I believe, strengthen the surgical specialties by providing a unity of basic surgical training. If this is not done the essential independence of the surgical specialties may become lost. As Harvey Cushing so aptly said, "They are justified only by their continued productiveness."

A year, or possibly two years, of general surgical training will provide the best possible foundation for the surgical specialist in the future. It will open to the young trainee a broader approach to his particular field, which will without doubt lead to expansions in that field. Training in general surgery may not seem to be essential to many of the older men in special fields of surgery, but it has not been many years since the older general surgeons were convinced that a background of anatomy and pathology was completely adequate for the embryo surgeon. The possession of certain specialized skills is not incompatible with a knowledge of fundamental surgical principles. The two complement each other and will inevitably lead to the advancement of knowledge in the special fields.

There are few special fields in which the trainee would not be benefited by a year or more of general surgical training. This is certainly true of urology, gynecology and orthopedic surgery. It is equally true for those who wish to enter the thoracic and cardiovascular fields. The candidates for examination in plastic surgery must now have been certified by the American Board of Surgery.

The young specialist who has been trained first in general surgery in a clinic where he has had an opportunity to do investigative work, or to come in close contact with those who are doing it, and who has acquired the ability to care for patients with all types of surgical lesions will necessarily have a broader outlook on his own work and be less limited in the technics which he brings to it. It is from such men that we may well expect leadership and the ability to expand the boundaries of knowledge in the surgical specialties in the future.

The various boards, in an effort to raise the standards of practice and to provide a gauge by which surgical specialists may be measured have attempted to standardize training. In their justifiable zeal to protect the public they have carefully and thoughtfully defined what the training for a particular field shall be. They have in many instances detailed the amount and type of basic training which candidates for certification must have. Even the number of years of training has been specified, evidently on the assumption that all training is equal in the opportunities and responsibilities presented. The experience of examiners during the past ten years has demonstrated that this is by no means true. In spite of certain defects the boards must continue to be responsible for the safeguarding of the qualifications of surgeons and of surgical specialists.

Doctor Da Costa frequently alluded to what he called "the system" in certain hospitals where "some of the staff get more than they deserve and

most get less than they need " He decried the policy which he believed to be all too common in 1915 of not appointing members of the staff purely for fitness, but of permitting personal reasons to sway the result. A period of graded training leading to certification will provide young men in the future with the necessary background which will bring recognition. If the professional staffs of our hospitals fail to recognize this, the lay boards which direct them, must provide the necessary recognition. Certification, if it is to be a hallmark of accomplishment, will signify broad education and motivated training, a full realization that the obligations of certification entails superior knowledge and skill and the ability to render distinctive service. If certification continues to signify this with increasing clarity, surgical practice will continue to improve, and the boards will play an even more important role as the custodians of general and special surgical training.

As long as medicine and surgery are further separated, they are unfortunately apt to become further distorted, for as Buckle has said, "The philosophy of any subject (that is the truth of it) is not at its center, but on the periphery where it impinges on all the other sciences." Surgery, as part of medicine, must, therefore, increasingly draw closer to the essential principles of medicine. Surgery and its specialties are not in need of new mandates—these are clear. Their function is to provide the best possible care for patients, to add to the knowledge of the field, and to train young men, not alone in the handicraft of the surgeon or the surgical specialist but in the broadest aspects of disease.

The advancement of existing knowledge and the creation of new knowledge lies in research. I am convinced that the men interested in the development of surgical laboratories, and working in them, should maintain an intimate contact with clinical surgery. These laboratories are in reality laboratories of experimental physiology and pathology as applied to surgery. The young men working in these laboratories may be concerned with work of a fundamental nature or of immediate clinical importance. It really makes little difference for it is difficult at times to define what is and what is not fundamental research. The important thing is that such training will broaden the education of the young men engaged in it, for it will interest them in the larger aspects of disease. It will make them more critical, and it probably will enhance their eventual specialties, for they will be more apt to investigate those conditions in which they may become particularly interested. The future of the science of surgery is dependent upon such activities.

From the researches on nutrition of the early German physiologists and physiologic chemists to the present seems a long time, but there has occurred an orderly development in our knowledge of this subject which has been of incalculable value to surgeons and their patients. Starling demonstrated the importance of the plasma protein in keeping fluids in blood vessels and in their return to vessels once they have escaped. The researches of George Whipple and his associates provided fundamental observations on the regeneration of plasma protein under a wide variety of circumstances. William

Rose and his co-workers gave us new insight into the essential character of various amino acids in growth. And from these and many other fundamental studies has come new insight into the problems which many surgical patients present.

The importance of edema in conditioning respiratory complications after anesthesia and operation, the relation between hypoproteinemia and the inability of new gastrointestinal stomata to function, the part played by protein undernutrition and a vitamin C deficiency in the failure of incised wounds or decubitus ulcers to heal are now generally accepted. But protein undernutrition may result in faulty callus formation after fractures, and a similar circumstance may retard regeneration in an organ, such as the liver, which, even under only moderately favorable circumstances, possesses an irresistible urge to regenerate. It is more than probable that the two biologic factors assisting in the control of infection are dependent upon the nutritional state of the patient.

In this field, as in many others, surgery has drawn heavily upon the fundamental researches of many investigators in many fields of activity, but surgeons have made and are continuing to make contributions to our knowledge of nutrition. Robert Elman, in fact, was the first to become interested in the parenteral administration of protein derivatives, and he has stimulated an untold amount of work in this field.

The surgeons of the future will not tolerate the divorce of the hand from the brain, and the surgery of the future will not again be merely a handicraft. The surgical specialties dependent upon their productiveness will continue to multiply, but they may from time to time as Harvey Cushing prophesied "Come back to the mother tree for further suckling." In the surgery of the future the individualist will be left by the roadside, for after all surgery is part of that broader field of experimental pathology to which all the medical sciences belong.

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UTERINE ANOMALY DUPLICATION OF UTERUS, THREE TUBES AND THREE OVARIES

Report of a Case
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CONGENITAL ANOMALIES of the uterus are the subject of considerable interest from an anatomic standpoint. These anomalies frequently produce serious obstetric complications as well as surgical complications.

An unusual case of anatomic anomaly of the reproductive organs warrants reporting because of failure to find any like case described in the literature. A search through the literature did not reveal any description of a case of this type. Curtis' *Monograph on Gynecology and Obstetrics*, Davis' *Monograph on Gynecology and Obstetrics*, as well as De Lee's textbook, do not describe a case of this type. In a personal communication from Dr. J. C. Mason of the Mayo Clinic, he stated that he had not heard of a similar case.

In reviewing the classifications of malformations of the uterus, particularly Jarcho's special article on the subject, it would seem that the uterus didelphys would be the classification in which to place such a case. However, this particular case does not conform to the usual description, but rather falls under one of the three differentiations suggested by Chiari.

- (1) Ovaria accessoria small split off ovarian and tubal fragments representing small appendages
- (2) Ovaria bi/or pluripartita division process of the original ovarian anlage, only two tubes
- (3) True excess formation of the ovaries (extremely rare) with formation of corresponding supernumerary tubes

The third classification of Chiari comes as near to the proper one for this case as I am able to find in the literature.

The obstetrical history in this case occurred many years before the patient came to operation, and has no bearing on the present condition.

The incident of hematometra in one side in these cases is rather common and is often the cause of surgical interference. In this case, hematometra occurred in a menopausal woman three years after the last menstrual period.

CASE HISTORY

The patient is a white female, 54 years of age, who was first seen October 11, 1946. She had been married 33 years. She was brought into the hospital by ambulance as an emergency because of severe pain in the lower right quadrant and pressure pain of the rectum. The pain had been severe for the past three or four days. The primary cause for emergency admission was a sudden rising of temperature without chill.

DUPLICATION OF UTERUS

Physical Examination The positive findings of a general physical examination were those of temperature of 101.4, pulse rate of 140, systolic blood pressure of 180, diastolic blood pressure of 110, rough aortic and pulmonic second sounds, occasional extrasystole, moderate cardiac hypertrophy. Abdominal examination was negative except for pain on palpation of the lower right quadrant. Pelvic examination disclosed that the vaginal vault was occluded

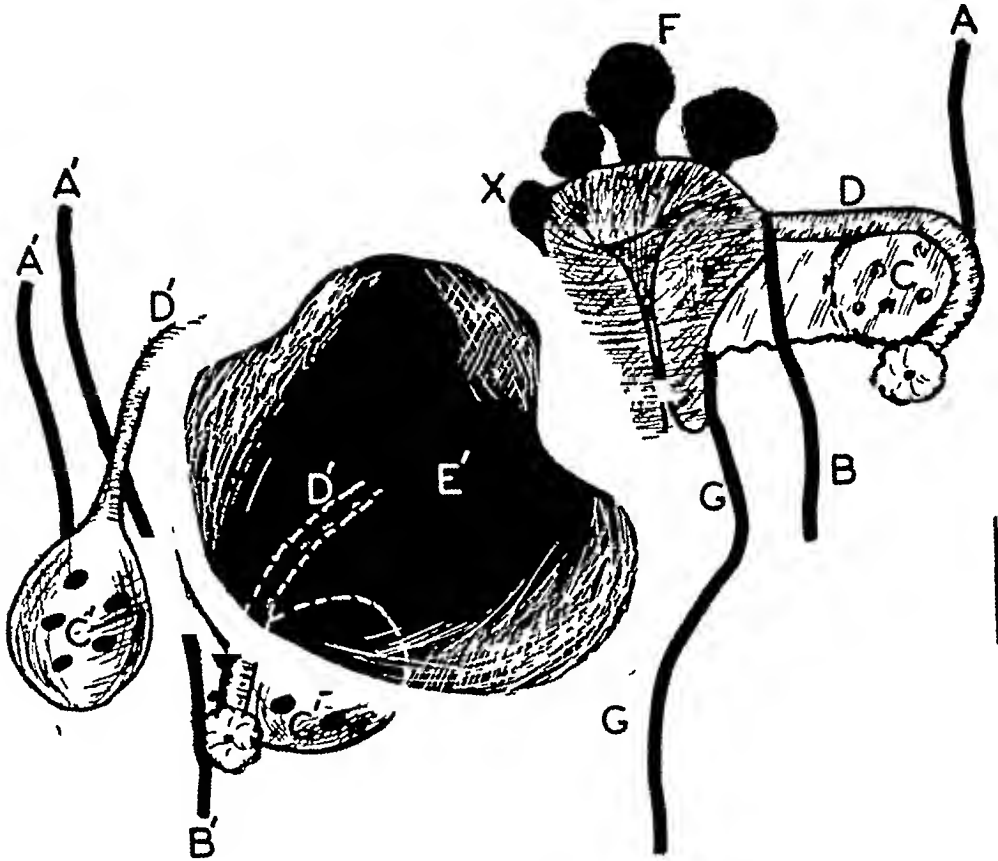


FIG 1—Diagrammatic drawing from the fresh specimen view from the anterior surface. A Ovarian vessels of the left ovary of the left uterus, A' Ovarian vessels to the ovaries of the right uterus, B Left round ligament of the left uterus, B' Round ligament attached to the right side of the right uterus, C Ovary of the left uterus, C' Ovaries of the right uterus, D Left tube of the left uterus, X The fundal stump of a tube arising on the right side of the left uterus, this structure having been previously removed according to the clinical history; D' Tubes of the right uterus, E Body of the left uterus, E' Blood-filled cavity of the right uterus, F Pedunculated fibroids on the left uterus, G Vagina

in the fornix except for a narrow slit in the left vaginal wall which would not admit the examining finger. A soft fluctuant mass was found deep in the pelvis on the right side, extending downward below the level of the cervix on the right side and bulging laterally to occlude the vaginal fornix. There was a hard nodular mass to be felt on the left side which was believed to be a uterus with fibroids. The fluctuant mass on the right was believed to be either a uterine cavity full of fluid or a ligamentous ovarian cyst. On speculum examination the cervix could not be seen but a large bulging mass could be seen in the upper vault of the vagina, excluding the entire fornix except for a

small slit on the left side between the left vaginal wall and the bulging surface of the right vaginal wall. Through this opening a small probe could be passed and a hard nodular structure was felt which was assumed to be a small cervix.

The history of past attacks was as follows:

Menstruation began at the age of 13 and was markedly irregular from the onset to the sixteenth year of age, with severe headaches attending each period. At the age of 16 she had her first attack of lower right abdominal pain. She also had a pain low in the rectal region. This is the same type of painful distress that she complained of upon admission. She was operated upon at the age of 16 for what was presumed to be appendicitis. The operation was performed in a small mining hospital, and there are no records obtainable. So far as the patient can recall, the appendix was removed and she was told there was a small tumor removed which was called a fibroid, and that one ovary was also removed with an adjoining tube. After recovering from this operation her menstrual periods became regular, occurring every 28 days and lasting from three to four days. This regularity continued until the age of 31 at which time, though the menstrual periods occurred regularly, she had a recurrent attack of pelvic distress and was again operated upon. An exploratory operation at that time revealed a pregnancy in what was described to her as one uterus, and also revealed a tumor mass on the right side, also the presence of a fibroid growing from the uterus on the left side. The fibroid tumor was removed at this operation. No other procedure was done so far as the patient can recall. This operative record is also unobtainable. However, she was told that she was pregnant, and seven days postoperative she expelled a fetus which was said to be of five months' gestation, and which could be identified as a male. Following this second operation her periods were regular and for several years she had no distress. Prior to her menopausal change her periods were associated with severe headache. Periods stopped abruptly at the age of 51, approximately three years before she was examined at this clinic.

On further questioning after the operation, the patient stated that one of the doctors who operated on her the first time told her she had four ovaries and four tubes. This statement is borne out by our subsequent findings.

In addition to her pelvic history, patient gave a history of food dyscrasia, particularly with fats, associated with gas and belching, indicating some gallbladder disturbance.

Laboratory findings on admission were as follows:

Blood count showed a hemoglobin of 84 per cent, 4,370,000 red cells, 8,300 white cells, 76 polys, 8 stabs and 24 lymphs. Clotting time was 12 minutes. The non-protein nitrogen content was 40 mgm per 100 cc of blood. The Kahn and Mazzini were both negative. Voided specimen was cloudy, pH was 6, specific gravity 1.005, albumin I on the basis of IV, and there was no sugar.

At the time of admission to the hospital the patient's condition was acute. The low pelvic pain which had been present for several days had become severe and was constant in character. It was decided that exploratory surgery

was advisable. She was therefore operated October 12, 1946, with a tentative diagnosis of pelvic mass on the right side which could either be a uterus with retained menses or an interligamentous ovarian cyst, and fibroids of the uterus. Also, malformation of the pelvic organs.

Operative Procedure Through a midline incision excising the old scar the abdomen was opened and after proceeding with the dissection of adhesions and freeing the pelvic organs from the bowel and omentum the following anatomical structures could be identified: there was a uterus on the left containing fibroids. There was an ovary far to the left, normal in appearance, and a chronic infected tube properly located. On the right side of this uterus there was a small nodular mass that appeared to be the site of a previously existing tube which had been removed. Many adhesions of the omentum were dissected from this area. There could be no ovary identified lateral to the fundus of the uterus containing fibroids. About the midline a cystic ovary could be identified and following the tube toward its attachment we found a large mass—the fluctuant soft mass felt on examination. The tube entered this mass and anterior to the tube a round ligament was identified. This was the right uterus. The cavity of this uterus was full of brown material which was retained menses. There was also a round ligament identified from the left uterus and from its fundal insertion it could be traced to the left inguinal insertion. On freeing the right uterus as a fluctuant mass another ovary and tube were found attached in the proper relations which had hitherto been hidden because of their position deep in the cul de sac. General abdominal exploration revealed fiddle-string adhesions between the diaphragm and the liver which suggested the possibility of Neisserian infection at a previous time. The gallbladder was bound in a mass of fat and omentum which was adhered to the liver edge. No stones could be palpated. The head of the cecum was bound down in such a mass of adhesions that it was deemed best not to disturb it to try and determine whether or not the appendix had been previously removed. On removing the pelvic structures an ovarian vessel was identified supplying blood to the left ovary of the left uterus. We were unable to identify a separate vessel which might have supplied the right ovary of the left uterus. There were two distinct ovarian vessel groups supplying each of the two ovaries of the right uterus. These were separated by a distance of one and one-half inch. They were separately ligated. The ureter on the right side could not be identified. The ureter on the left side was identified. It was necessary to remove the left uterus and open the vaginal vault on the left side to approach and remove the very low-lying right uterus. A pan-hysterectomy was done, metaphen sponge was placed in the vagina, the vaginal mucous membrane was closed by opposing the mucous membrane with interrupted #1 chromic sutures placed in the muscularis. The cardinal ligaments were sutured to the cervical stump on either side, uterosacrals were caught in a circular suture which contained each uterosacral ligament, the two round ligaments which were identified, and the stump of the cervix. There was a very large dead space left on the right side which was dry when the peri-

toneum was closed. It was possible to find sufficient peritoneum to cover all the raw surfaces. The abdomen was closed without drainage.

On examining the pathologic specimen postoperatively from a surgical standpoint, it appeared that there was a uterus on the left side with an attached tube and ovary and a round ligament attachment. There was a large fibroid in the fundus of the uterus and a large fibroid in the region of the cervix and three small pedunculated fibroids on the outside of the uterus posteriorly. There was an area on the right side of the left uterus which appeared like the site of a tube that had been attached at sometime. The uterus on the right side was thin-walled, there was a large cavity containing a thick brownish-green material which was retained menstruum. This uterus had a tube and ovary on the right horn and a tube and ovary on the left horn. The cervix of the right uterus was completely closed at the internal os. There was a continuous fibrous band from the internal os downward about one inch. The cervix of the left uterus had a very fine narrow canal which would open into the vagina. We therefore had a specimen consisting of three ovaries, three tubes and two uteri.

The report of the pathologist is as follows:

"Congenital malformation of the reproductive organs. Two uteri, one with two tubes and two ovaries, the other with one tube and one ovary,

Multiple fibromyomata, subserous and intramural, of one uterus,

Atrophic ovaries attached to the myomatous uterus,

Hematometrium and wall atrophy of the second uterus,

Hematosalpinx and endometrioma of the ovary attached to the second uterus,

Massive old adhesions around the second uterus, tube and ovary."

The pathology was reported by Dr. Siegfried Werthammer, Huntington, West Virginia.

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THE SELECTION OF PATIENTS FOR THORACOLUMBAR SYMPATHECTOMY

Description of a Set of Rules for the Elimination of Failures and Fatalities

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IN A SERIES OF 375 PATIENTS undergoing thoracolumbar sympathectomy we have had 38 fatalities either in the hospital or within 6 months of the operation. In an attempt to avoid future deaths we have analyzed the status of this group of 38 patients and also that of the remaining 337 patients and have arrived inductively at a set of rules which would eliminate all but 2.5 per cent of the mortality. The figure 2.5 per cent is reasonably low in view of the fact that each patient undergoes two major operative procedures and in this group of patients, many are recognized as poor risks.

Following the lead of Keith, Wagener and Barker¹ who graded the eye-grounds of hypertensive patients from 0 to 4 plus we have utilized a similar method of grading the cerebral, cardiac and renal status of each patient. In order to do this satisfactorily one needs in addition to a careful history and physical examination the following studies: fundal examination, electrocardiography, six foot heart plate, a concentration test (pitressin or Mosen-thal), urea clearance, blood urea nitrogen, non-protein nitrogen, creatinine and urinalysis. Intravenous urography was applied routinely in the work-up of the first 150 patients until one death and two marked reactions associated with the injection of the dye caused us to abandon it unless there was a significant indication for its use. A complete blood count, sodium amytal test (nine gr divided into three hourly doses) and a basal metabolism are desirable but not emphasized in evaluating the patient's status for sympathectomy. A high basal metabolic rate associated with the hypertension makes one suspicious of a pheochromocytoma². The sodium amytal test is a good indication of the probable postoperative blood pressure result but is not absolutely accurate as a prognosticator in any given case³. The Etamon test (tetraethylammonium chloride) has been studied by Dr. C. A. Poindexter and Doctor Tamagna and correlated with the sodium amytal test in more than 30 patients. In approximately 75 per cent of the patients the two tests were correlated exactly, while in the remaining 25 per cent there was a variation in the Etamon test in both directions from the sodium amytal test. No post-operative evaluation of its possible prognostic usefulness has been made.

In Table I we have outlined the definitions which serve to evaluate the degree of damage present in each of the four important organs, brain, eye, heart and kidney, as a result of the hypertensive state. In Table II a group of rules are set forth for the selection of patients based on the definitions as described.

In the preoperative evaluation of the status of an organ problems such as the following may arise the renal concentration test may be only 1,013 whereas the urea clearance may be 85 per cent of normal. In that case we have one test placing the kidney in a three plus category and the other in a one

TABLE I—*Definitions**In general in any system*

- 0 Normal
- 1 +Slight or mild changes
- 2 +Moderate changes
- 3 +Moderate changes
- 4 +Advanced or marked changes

Cerebral

- 0 No symptoms or signs
- 1 +Headaches and/or dizziness and nervousness
- 2 +Above plus no-bleeds and/or occipital headaches
- 3 +Above plus paresthesia
- 4 +Stroke or encephalopathy or confusion

Eyes

- 0 Normal
- 1 +Arteriolar narrowing
- 2 +Above and arterio venous nicking
- 3 +Above plus hemorrhages and exudates
- 4 +Above plus papilledema

Cardiac

- 0 No symptoms or signs
- 1 +Slight symptoms and/or slight cardiac enlargement and slight E K G changes
- 2 +Moderate symptoms and/or moderate X ray enlargement and moderate E K G changes
- 3 +Marked symptoms and/or marked enlargement and marked E K G changes
- 4 +Coronary occlusion or congestive heart failure

Renal

- 0 Normal
- 1 +Nocturia but concentration 1 024 or more and urea clearance 75% or more
- 2 +Urea clearance 40-75% concentration 1 015-1 023
- 3 +Urea clearance less than 40% concentrate less than 1 015 normal blood chemistry
- 4 +Persistent elevation of N P N to 45 mgms or more and B U N to 25 mgms or more

TABLE II—*Rules**A Contraindications to thoracolumbar sympathectomy*

- 1 4+Renal
- 2 4+Cardiac in which congestive heart failure is unremitting or if coronary occlusion is within 3 months
- 3 4+Cerebral if confusion exists or if a stroke within 3 months
- 4 If there are two 4+ other than eyes
- 5 If total count equals 11 or more pluses

B Indications for thoracolumbar sympathectomy

- 1 All cases are operable in which there is no contraindication rule
- 2 From the viewpoint of minimal involvement Operation is probably advisable in patients with persistent hypertension associated with definite though minimal objective changes in any one of the four systems

plus. We, therefore, have averaged the two and considered the degree of damage as two plus. Similarly a patient may have excellent cardiac function, *i e.*, no dyspnea or angina in climbing three flights of steps and yet the electrocardiogram and chest plate may show moderate (two plus) changes. It is a matter of judgment whether the patient should be classified as a two plus or a one plus cardiac.

A system such as this one, not based on mathematical data, must be interpreted in the light of clinical judgment, and implies that the surgeon operating on these patients has had moderate experience with the technic of thoracolumbar sympathectomy. The rules have aided us considerably, however, since their formulation and may be of help to internists and surgeons interested in the surgical treatment of hypertension.

A few comments on special aspects of the problem of selecting patients for surgical therapy should be added.

1 Generalized arteriosclerosis of a significant degree is a bad sign and should exclude a case of borderline acceptability.

2 Age is not a factor in selection. In our patients 50 years or older (two in the sixties) the same percentage of worthwhile results (*i e*, 67 per cent) was noted as in the entire group operated upon.⁴

If, in this series of 375 patients, the contraindication rules outlined had been applied, then 25 patients who have done well would have been refused operation. Among the remaining 350 patients there were 38 deaths either in the hospital or within six months post-operatively, 30 of these would have been eliminated by the rules outlined in this paper, leaving eight deaths in a total of 320 patients, a mortality of 2.5 per cent.

The problem of determining which of the 312 patients, who were within the limits of the contraindication rules and who lived through the operative procedures, would derive excellent results and which ones would derive only fair results or no benefit, is a most difficult one. Smithwick has emphasized that females Type 1 (narrow) pulse pressure obtain the best results and that males with Type 3 (wide) pulse pressure do poorly. We have seen many exceptions to this rule and as yet have found no system which will work in the majority of the cases. Therefore at present we adhere to the policy of advising an extensive thoracolumbar sympathectomy on all patients who have a sustained hypertension, unresponsive to the usual medical management including the rice diet, and who have definite though mild objective changes in one or more of the four major organs discussed above.

It should be emphasized again that the set of rules discussed in this paper is not a substitute for clinical judgment and individual consideration of each patient but rather serves as a useful adjunct and as a working basis for the elimination of poor risk cases.

SUMMARY

On the basis of an experience with 375 hypertensive patients undergoing thoracolumbar sympathectomy we have arrived inductively at a set of rules which would have eliminated 30 of the 38 deaths which occurred in this series either in the hospital or within six months postoperatively. A discussion of the rules and the definitions on which they are based has been given.

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CONSTRUCTIVE PERICARDITIS WITH TUBERCULOUS INTRA-PERICARDIAL ABSCESS TREATED BY STREPTOMYCIN*

Report of a Case

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THE ROLE OF TUBERCLE BACILLUS as a causative agent for constrictive pericarditis is recognized by recent investigators^{1, 2, 3} Pleural effusion, a common finding in patients with constrictive pericarditis, is thought to be part of a polyserositis rather than a sequela of the constrictive pericarditis³

Sellors³ reports that pockets of fluid or inspissated debris are often present in the pericardium A survey of the available literature,¹⁻¹² however, reveals no report of a definite intrapericardial abscess from which acid-fast organisms were recovered, accompanying the constrictive process No cases have been reported in which streptomycin was used either pre- or postoperatively

Our case of constrictive pericardial involvement followed the typical course with bilateral pleural effusion and pericardial effusion followed by slowly developing signs of venous obstruction At operation a constrictive pericarditis with an intrapericardial abscess was found After pericardectomy streptomycin therapy was administered and the patient recovered without a draining sinus in spite of the proven presence of tubercle bacillus in the intrapericardial pus

CASE HISTORY

L. S., a 20 year old Negro male, was admitted to the Veterans Administration Hospital at Oteen, North Carolina, on September 9, 1944 He was inducted in December, 1941 In December, 1943, while in England, he had what was termed atypical pneumonia and was off duty for a period of six weeks Roentgen-ray at this time was said to have shown a normal heart shadow Six weeks later, in May, 1944, he became ill with chest pain, cough, shortness of breath and fever Roentgen-ray examination in an Army hospital revealed an enlarged cardiac shadow The tentative diagnosis at this time was pericarditis, probably of rheumatic origin Soon after admission the pericardium was tapped and 80 cc of straw-colored fluid was obtained Cultures of this fluid were negative for acid-fast and pyogenic organisms Fever, however, persisted He stated that fluid was removed subsequently, twice from the pericardium and once from the left pleural cavity In July, 1944 he was returned to a United States Army Hospital where he was found to have a residual left pleural effusion and a recent effusion on the right

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A right thoracentesis, however, was unproductive. His temperature ranged up to 104°F and he was kept on salicylates. The sputum was repeatedly negative for tubercle bacillus, but the tuberculin test was strongly positive. He was then transferred to the Oteen Hospital where a diagnosis of polyserositis with a pericarditis was made. The temperature ranged from 99 to 101° F from September 9, 1944, to January 9, 1945, when it approached normal and remained there with occasional minor elevations.

During his entire period at Oteen, numerous concentrated sputum studies were negative for tubercle bacilli, as were cultures and guinea pig inoculation made from concentrated sputum and from gastric washings. On admission, fluid was present in both right and left pleural cavities which, when removed by thoracentesis, proved to be negative for tubercle bacilli and any other organisms. The urine showed a trace of albumin on numerous occasions, with an occasional white blood cell and occasional granular casts. The liver was enlarged two fingerbreaths below the costal margin. There was moderate ascites. Abdominal paracentesis on September 12, 1944, yielded 80 cc of straw-colored fluid which was negative on culture for any pathological organisms. Dyspnea became progressively more severe. Edema of the ankles was present. Roentgen-ray showed that the borders of the heart were obscured by fluid collection, but the heart shadow was considered widened. By February 28, 1946, the heart was reported to be globular in type and not unduly enlarged. On June 5, 1946, the roentgenologist reported the heart to be normal in size, although it was displaced a little to the right. There was obliteration of the costophrenic angle bilaterally due to the residuals of pleuritis.

The venous pressure on July 2, 1945, was 160 mm of water. The circulation time was 13 seconds from arm to tongue. By June 5, 1946, the venous pressure had risen to 240 mm and with pressure over the liver was elevated to 270 mm. Circulation time, however, was only 11 seconds. There was marked dilatation of the veins of the neck and upper chest. A diagnosis of constrictive pericarditis was made and a pericardectomy performed June 6, 1946. The pericardium was thick and adherent but a line of cleavage was rather easily identified and the pericardium removed by blunt and sharp dissection, beginning with the left ventricle. In the upper lateral and posterior portions of the pericardium covering the left ventricle was a dense area of adhesions which, when separated by sharp dissection, opened into a pocket containing approximately three ounces of thick, creamy pus. This pus was sent to the laboratory and was positive on smear for acid-fast bacilli. The excision of the pericardium was then carried over to the right ventricle. Following the excision of the pericardium the cardiac impulse seemed to be greatly improved. One gram of streptomycin was dissolved in saline and was instilled into the remains of the pericardial sac. The wound was closed tightly without drainage.

The pathologist reported the pericardium to be 0.5 cm in thickness. Microsection revealed thickened and hyalinized strands of connective tissue with attached granulation tissue consisting of large and small mononuclear cells, red cells, fibroblasts and new formed vessels. A pathologic diagnosis of chronic granuloma was made.

The pathologic reports in this case tend to explain the confusion which is apparent in the literature as to the role of tuberculosis in the etiology of constrictive pericarditis. Here we had definite proof of the presence of acid-fast bacilli in the pus obtained from the intrapericardial abscess. Microscopic examination of the tissue, however, did not give a clear-cut picture of tuberculosis and the pathologist was unable to make a diagnosis other than chronic granuloma.

The day following the operation the venous pressure which had been 240 mm of water preoperatively was found to be 132 mm. Circulation time was 13 seconds. The venous pressure gradually rose, however, until on August 10, 1946, it had again reached 220 mm. Circulation time was 16 seconds at that time. Following the operation, streptomycin, 2 grams daily, was given until July 22, 1946. There was a small amount of drainage of a serosanguineous nature for about one month after the operation but all dressings were discarded on July 3, 1946, and the wound remained dry. Clinically the

patient improved markedly and was discharged from the hospital on November 7, 1946, without ankle edema

On July 10, 1947 thirteen months after the pericardectomy, the patient stated in a letter that he was not short of breath and could walk ten blocks without difficulty. He reported that his ankles were not swollen and that his abdomen was not enlarged. If he climbed a flight of stairs at a rapid rate, however, he became short of breath. Circulation time and venous pressure studies were not available at this time.

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"FUNCTIONAL" SUBCLAVIAN ARTERIAL MURMUR POSSIBLE RELATION TO SCALENUS ANTICUS SYNDROME, COSTOCLAVICULAR COMPRESSION, OR THE NEUROVASCULAR SYNDROME OF WRIGHT

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THE PURPOSE OF THIS PAPER IS to present cases of apparently normal individuals in whom was found, on routine pre- and re-employment examination, a group of signs—and no symptoms—referable to the subclavian artery of one or both sides, and to speculate, in the light of certain findings, (particularly the evidences of arterial obstruction), on the possible origin and significance of these signs

INTRODUCTION

Consulting standard texts on physical diagnosis, the following comments are found "Constriction of larger vessels will produce murmurs. An example is the systolic murmur sometimes heard a short distance below the clavicle due to the narrowing of the subclavian in some part of its course",¹ "In coarctation of the aorta, there is a soft systolic murmur over the innominate, carotid and subclavian arteries. This murmur is often heard at the angle of the left scapula",² and "Subclavian (functional) murmurs, heard best in inspiration, are most common in men and are modified by position of the arm. Subclavian murmurs possess no pathologic significance, they are generally due to constriction of the artery between the clavicle and first rib, although may be fibroid disease of the pleura. Landis found of 31 cases 20 associated with pulmonary tuberculosis. The fact that it is heard more on the left suggests anatomical variation".³ Perusal of the Index Medicus for the years 1940 through 1945 under the titles "arteries," "murmurs" (nothing listed), "muscles, scalene," and "pulse" reveal nothing by title that might bear directly on the explanation of the murmur in question. References to the signs of subclavian or axillary arterial obstruction are cited as they apply to the discussion (v1)

CLINICAL MATERIAL

These patients, representing 21 of 2619 applicants for position, or 0.8 per cent, came to attention solely because of a systolic murmur over the subclavian artery (or arteries) which was discovered incidental to the routine examination of the chest. The first 11 of this group were passed over with no special examination, the condition being assigned in the examiner's mind to the class of functional murmurs (see Table I). Later, however, more detailed examination of ten persons was performed with the results that will be brought out later in this communication.

Twenty of the 21 persons were females (ratio of total females to males was only 7:1), the average age was 21 years, and the murmur predominated

SUBCLAVIAN ARTERIAL MURMUR

on the left, appearing on that side alone 11 times, on the right side alone only once, bilaterally five times, and in four cases the laterality was not noted. The personnel examined was entirely of Mexican extraction, approximately two thirds of whom were born in the United States. As far as could be determined, the cases demonstrating a murmur had nothing in common in their past histories, and as usual in this age group, were generally negative on physical examination. Exceptions to this are noted in full. Special care was taken to determine that this was not in any case an "underground" murmur from a valvular heart disease and no patient had signs or symptoms suggestive of heart disease. A routine Mazzini test was negative in all cases, a routine

TABLE I—11 Cases No details as to B P

Name	Age	Sex	Side of Murmur		Remarks
			Right	Left	
EG	20	F		*	Fluoroscopy negative
AG	21	F		*	Fluoroscopy negative
ME	18	F	X	X	Fluoroscopy negative
SM	23	F		X	Fluoroscopy negative
RG	20	F		X	Fluoroscopy negative
ME	19	F	X		Fluoroscopy negative Present on inspiration only
MGP	38	M		X	Fluor Undiagnosed pulsation of abnormal amplitude, left border of heart above ventricle—? No cardiac murmur
VD	21	F		X	Fluoroscopy negative
FT		F		*	Fluoroscopy negative
TT		F		X	Fluoroscopy negative
MBV		F		*	Murmur on inspiration only
Average 10 F					
11	22 5	1 M	2	6	

* Presence of murmur recorded, but laterality not noted

Roentgen-ray and/or fluoroscopy of the chest was negative in all except one. This worker, Case 3, has had apical tuberculosis, minimal, and now inactive, this finding is of four and one-half years duration at the time of this writing and the patient has been asymptomatic during that period, maintaining normal weight and working eight hours per day at a moving belt. It will be noted that this one case of tuberculosis is on the side opposite that of the murmur. The incidence of active tuberculosis in the total group of employees examined was 1.2 per cent, but another 2 per cent are under periodic surveillance as "suspicious" cases and probably represent healed lesions. This incidence of relation of the murmur to tuberculosis is insignificant compared to the representation, above cited, by Landis.³

It is important to add that, although no symptoms were presented, neurologic examination was nevertheless done in all cases (i.e., pin prick and cotton), and no instance of cervical plexus interruption was found.

DESCRIPTION OF THE MURMUR

The murmur itself, as may be correctly inferred from the fact that it was found on a brief routine examination, was constant for the individual, fairly

loud and definite. It would not always have been heard were it not routine with the examiner to have the patient place the hands on the hips for the auscultation of the axillae, because the murmur is sometimes heard only on elevation occurring with this position. On other occasions the murmur was heard in the relaxed sitting position, but not heard in the recumbent position. When heard in the relaxed sitting position, or in the hands-on-hips position, the murmur was always accentuated by deep inspiration or gradual abduction of the arm. The greater the abduction, the louder the murmur, up to abduction of 135 to 150 degrees (Nos. 1, 2, 5, 7, 9, and 10—see Table II), when the murmur disappeared altogether because blood flow to the arm as ascertained by radial pulse and blood pressure* had been obliterated. In four cases (Nos. 2, 3, 7, and 9), the murmur had been heard from four to six years previous to its more detailed investigation. These patients had neither developed symptoms nor demonstrated any appreciable change in the nature of the murmur.

The accentuation of the murmur upon elevation of the arm, suggested the performance of a group of somewhat unorthodox tests to supply information for functional analysis. With the patient seated, blood pressure was taken in one arm, at first relaxed and then voluntarily elevated above the head to 180 degrees abduction. This was then repeated on the opposite side. Following these readings, a blood pressure was taken on one thigh using the popliteal artery as the point of auscultation. (This latter determination was made to further exclude in an objective manner possible cases of coarctation, and in no case was the blood pressure in the lower extremities lower than that of the upper.) Now, in order to correlate the various readings for easy interpretation, a mean blood pressure was calculated for each arm, averaging the systolic readings relaxed ("down" in the chart) with that in extreme abduction ("up" in the chart) and similarly for the diastolic "down" and "up." By comparing these figures for the affected and unaffected sides, probably the most information concerning the blood flow to the arm is obtained—(Table II). Also, pulse pressure difference ("P P D") between the arm at rest and elevated was calculated for each side. The figures resulting from this calculation are less informative because, although an affected side may have had a lower mean blood pressure, the pulse pressure difference may actually appear to be less in the affected arm by reason of the fact that some of these vessels showed a moderate difference in blood pressure when comparing the two at rest. The typical cases, which showed a marked fall in pulse pressure on elevation of the affected side, did so by reason of the fact that the resting blood pressures were the same in both arms, or nearly so, (Cases 1, 2, 3, 6, 7, 8, and 10), the atypical cases with a difference in blood pressures in a resting position showed an equal or lesser fall of the P P D of the affected side, as compared with the normal. The bilateral cases can be compared only

* Palpation of brachial pulses too weak to be propagated to the radial artery were considered a function of the collateral circulation.

with the normal sides of unilateral cases.[†] Reference to Table II will show that in the presence of bilateral murmurs, the obstruction to blood flow is not usually the same on the two sides, and was generally greater on the left. In

TABLE II

Case No	Age	(All O+ or Females)		Blood Pressures—mm Hg						“PPD” †		Duration (yrs)	Remarks
		Side of Lesion		Right			Left						
		Rt	L	Down	Up	Mean B P	Down	Up	Mean B P	Rt	Left		
1	17	X	X	120 80	None	60 40	110 70	None	55 35	40	40	0	X-ray neg except horizontal and externally flared first ribs. Murmur on right only. Both pulses cease on elevation and cyanosis of both hands and poor capillary return (color).
2	20	X	X	140 75	105 55	122 65	122 60	98 44	110 52	15	8	6	Left radial ceases on elevation. Fluor negative. X-ray negative.
3	39		X	138 80	115 65	126 73	145 90	84 55	115 73	8	26	4½	Tbr rt apex, minimal, quest activity. Clinically o k.
4	16	X	X	135 75	None	63 37	105 70	70* ?	88 ?	60	?	0	Murmur heard only when head is rotated. X-ray. Pin point calcification left supraclavicular fossa.
5	22		X	115 80	85 70	100 75	90 60	70 45	80 53	20	5	0	Murmur on inspiration only. X-ray negative. On inspiration no reading in left arm, elevated PPD 35, under these circumstances.
6	26		X	128 75	90 60	109 68	128 70	75* ?	101 ?	23	?	0	X-ray negative.
7	22		X	110 70	70 50	90 60	110 70	0 ?	55 35	20	40	4	No pulse on left, elevated above 135 deg.
8	16	X	X	140 90	90 70	115 80	140 95	98 65	119 80	30	12	0	Slight thyroid enlargement but no bruit. X-ray negative. Bilateral murmur sitting position only.
9	26		X	125 80	85 70	105 75	90 70	0 ?	45 35	30	20	5	Murmur on inspiration only and elevation of arm. Blanching and tingling of left hand and forearm on elevation. X-ray negative.
10	16		X	115 80	90 50	103 65	115 80	55* ?	85 ?	—5	?	0	No brachial sound on elevation. Murmur only on elevation left arm. Complaint tingling of hands on elevation only. X-ray negative.

† 'PPD' is the remainder of the pulse pressure of "Down" minus the pulse pressure of "Up."

* Palpatorv. No sound heard over brachial. No significant oscillation of brachial.

*** The average fall of pressure on the normal sides were systolic 32.8, diastolic 16.7, pulse pressure 16.1. On the abnormal sides systolic 66.7, diastolic 50.8, pulse pressure 15.9. PPD, therefore, is significant only when comparing the two sides of a single case (All pressures are here and subsequently expressed in millimeters of mercury.)

some cases palpatory blood pressures were taken to represent the systolic pressure when no auscultation was possible over the brachial artery. In Cases 1, 2, and 7 auscultation was possible, but no radial pulse, nevertheless, could be found. This observation is explicable on the basis of peripheral arterial spasm: these patients complained of tingling or coldness on the affected side, and demonstrated varying degrees of ischemia of the elevated hand in comparison with the opposite side.

CASE REPORTS

From the information derived from the reports of previous investigators, the relation of the constriction of the subclavian-axillary segment to either scalenus anticus syndrome, costoclavicular mechanism,⁷ or the common anatomic arrangement of the coracoid process and pectoralis minor muscle and their relation to the vessels⁴—an attempt was made to pick out those cases which fell into each class on the basis of the maneuver which caused the obstruction, and in these cases the murmur. The following cases were all females, and to concur with one of Wright's statements, most of these individuals were not muscular and yet had markedly reduced blood pressures and pulse pressures due simply to hyperabduction. In six of the patients, the peripheral pulses disappeared.

In this series no case was observed which was thought to be a scalenus syndrome, and only one was thought to derive from costoclavicular compression, namely Case 1. The remainder followed the criteria of the obstruction of the artery, in varying degrees, on hyperabduction of the arm and, therefore, fell into the new anatomic classification brought out by Wright in the discussion of the neurovascular syndrome.

Case 1—B. T., 17 years, on routine examination was found to have the murmur on the right side only, just below the clavicle, but in comparing blood pressures, it was noticed that the left arm consistently gave 110/70, or less than that of the side of the lesion which was 120/80. On hyperabduction, the brachial and radial pulses disappeared bilaterally and there was cyanosis of both hands in a few seconds. Roentgen-ray demonstrated markedly flared first ribs, the upper surfaces being almost horizontal.

This was the only case which showed obstruction to the venous in excess of the arterial supply (collaterals)—if one is willing to interpret cyanosis as indicating this condition.

The relation of obliteration of peripheral pulse to deep inspiration as being of costoclavicular mechanism is strongly supported by the findings in the case which Schumacher⁷ operated under the diagnosis of subclavian aneurysm. Correlation is not conclusive because the author reports that the roentgenograms were suggestive of, but not definite for, costoclavicular compression and makes no note of having moved the arm to a position of hyperabduction when the artery was under direct observation. The murmur was present in the relaxed standing or sitting position, however, just as in this case.

The remainder of the cases were characteristic of the type of obstruction due to hyperabduction alone. It is my impression that had Wright made

routine blood pressure determination on his "normals" that a definite difference in resting blood pressures (between the two sides) would have been detected in some. This conclusion is based on the assumption that the following cases are examples of "asymptomatic neurovascular syndrome"—for want of a better term—and that some as yet undefined mechanism operates to obstruct the artery in these cases even before the exercises in abduction are begun. This is supported by the presence of the murmur in some cases in a relaxed sitting position.

Case 2.—A M, age 20, bilateral murmur (6 yrs duration) had a difference in resting blood pressures (140/75 on the right, 122/60 on the left) demonstrated reductions of the blood pressures and pulse pressures on hyperabduction: right 105/55, left 98/44. The left radial pulse was not palpable on elevation, but the blood pressure was obtained repeatedly, and with good oscillation of the mercury column.

Case 3.—R F, age 39, is the patient previously described who had a healed minimum tuberculosis of the right apex and in whom a murmur appeared on the left only, had resting blood pressures of 138/80 on the right and 145/90 on the left, but subsequently showed obstruction of such degree that the right blood pressure fell only to 116/65 on hyperabduction whereas the left fell to 84/55. She had no symptoms referable to the left arm during the known duration of the murmur, which was for 45 years.

Case 4.—A B, age 16, murmur present bilaterally but only when head was rotated to the corresponding side, suggesting a possible involvement of the scalenus. This was refuted by the observation that with hyperabduction alone no blood pressure was obtainable in the right arm and a palpable blood pressure of 70 was obtained on the left. It was also noted, on the left, that although the pulse could be felt in the cubital fossa, no oscillation of the mercury column was observed when the cuff was deflated from the resting systolic pressure to zero. This failure of the mercury column to oscillate was present in but 3 of 10 cases.

Case 5.—G A, 22, left murmur appeared on inspiration only. There was a difference in the resting blood pressures: right 115/80, left 90/60. On hyperabduction pressures fell to: right 85/70, left 70/45. Hyperabduction plus deep inspiration obliterated pulse in the left arm. The additional effects of inspiration and elevation of the arm suggest that the obstruction to this left subclavian artery could well be a combination of costoclavicular and coracoid process obstruction.

Case 6.—Z P, age 26, murmur on left only. Resting blood pressures: right 109/68, left 128/75, fell to: right 90/60 and left, no auscultatory point but could palpate pulse at 75 and again observed the phenomenon of complete lack of oscillation of the mercury column.

Case 7.—C H, age 22, murmur on left only. Resting blood pressures equal—110/70 fell to: right 70/50 and neither sound nor pulse could be obtained on the left elevated above 130 degree abduction. There has been no change in this murmur over a period of 4 years.

Case 8.—E H, age 16, had a bilateral murmur in the relaxed sitting position, and a slightly enlarged thyroid. Question of substernal thyroid or other mass was subsequently ruled out by roentgen-ray examination and the murmurs were not bruits characteristic of a vascular thyroid. Resting blood pressures were: right 140/90, left 140/95, on hyperabduction these fell to: right 90/70, left 98/65.

Case 9.—O F, age 26, left murmur in hands-on-hips position only. There was a difference in the resting blood pressures: right 125/80, left 105/75 and on hyperabduction

the right fell to 85/70 and the left was neither audible nor palpable. In addition, the patient complained of tingling of the left hand and forearm on hyperabduction and the left hand was noticed to be pale in contrast with the right.

Case 10—M M, age 16, had the murmur in hands-on-hips position only. Resting blood pressures were equal—115/80. On hyperabduction the right was 90/50, on the left the phenomenon of brachial pulsation with palpatory pressure of 55, but without any sound over the brachial and no oscillation of the mercury column, was observed. After the few moments required for the determination of the blood pressure, the patient complained of tingling of the hand in each instance.

DISCUSSION

By title, implication has been made that this interesting set of circumstances may be due to an asymptomatic form of scalenus obstruction, or to other compressions of the arterial trunk as described by Falconer and Weddell and by Wright. The suggestion of Landis that the murmur, being predominant on the left—if indeed this is the same murmur—is due to anatomic variation is well taken. What type of variation? Since none of these cases suffered any symptoms, it was not thought justified to try to explain the problem by surgical attack, only certain rationalizations can be drawn from the substance at hand. It would appear that if the artery were congenitally smaller at its origin, or intrinsically obstructed for any reason, the murmur would be constantly present. Furthermore, a murmur created by intrinsic obstruction would probably be transmitted into the common carotid, this one was not. It was, however, heard posteriorly at the upper border of the scapula, suggesting its transmission through the branches of the third portion of the subclavian artery. It would also seem that fibrous thickening of the dome of the pleura cannot be the commonest cause for the reason that thickening of such an extent should be radiographically demonstrable in a group of young, slender individuals such as these.

Granting that the factor creating the murmur is one of the structures in relation to the artery in its extrathoracic course, none of the presently recognized forms of scalenus compression will explain the progressive obstruction to the artery on elevation of the arm. In fact, it is now generally recognized that among the measures used for the conservative treatment of the clinical syndrome is the maneuver of elevating the arm, usually employed during the patient's sleeping hours. Were it conceivable that the subclavian artery traverses the substance of the scalenus anticus muscle as does an occasional variant of the brachial plexus,⁶ then this situation might obtain. Another form of subclavian compression, costoclavicular in operation,⁷ was discarded as a possible explanation (one exception) because the murmur was frequently heard with the arm at 45 degrees, the phase in which the clavicle is not in close approximation to the first rib. The authors of this last reference made the observation that their cases showed a relation of position to obliteration of the radial pulse in almost half the cases. The differences between these observations and mine are first, that the maneuver used was backward and downward bracing of the shoulders, and second, the fact that no murmur was

described, in connection with the changes in pulse, as is described in this communication. It bears out, however, that many persons have changes in circulation, differing from the accepted normal, which are not attended by any symptoms. The human experiments of Harpuda and Stein⁸ suggest that no symptoms of ischemia obtain until pressure falls below the usual diastolic pressure for the individual. Since none of these cases demonstrated this degree of obstruction at rest, the absence of symptoms is not surprising.

To demonstrate that cases with cervical ribs were recognized in this series when present, four cases were observed, all bilateral, an incidence of 0.15 per cent. These cases were all asymptomatic, had neither the murmur nor similar changes in blood pressure and pulse.

SUMMARY

1. An attempt has been made to throw some light on the previously described "functional" subclavian arterial murmur.

2. It has been demonstrated that persons with this murmur have definite obstruction of the subclavian artery, usually related to position but not necessarily so, and a characteristic attitude which causes the compression.

3. In the light of limited clinical material, the pro and con of the relation of this murmur to some variant of the scalenus anticus syndrome, costoclavicular compression, or the broader neurovascular syndrome of Wright, are discussed.

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PERIPHERAL NERVE SURGERY

Repair of Nerve Defects

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IN CIVILIAN PRACTICE surgeons are not often called upon to repair peripheral nerve injuries. Such patients as are seen usually have the type of injury which produces a minimal gap between the nerve ends that have to be sutured. Consequently, it is understandable that when a patient with a large nerve defect is presented, the surgeon is apt to be at a loss to answer the questions of whether the defect can be overcome and what methods must be used to accomplish it. During wartime, as happened in the last war, surgeons in large numbers, who had no previous experience, were called upon to do peripheral nerve surgery. In most instances, the nerve defects to be repaired were formidable ones. Unfortunately, these surgeons had no available source of detailed information stating the size defects which could be repaired successfully nor could they find information on the specific procedures to employ in a given instance for overcoming the defect. As a result, errors were frequently made.

At times nerve injuries were classed as irreparable, when a primary suture could have been done. Probably of equal importance is the fact that two-stage procedures were often used in cases that could have been better repaired at a single operation. Nerve grafts were performed (with uniform failure) on some patients who could have had a primary nerve suture with relative ease.

Babcock^{1, 2} has listed the approximate gaps which can be overcome and his table was reproduced by Pollock and Davis³. Babcock's figures were admittedly estimations, and we found these estimations at considerable variance with our measurements.

It is our purpose in this paper to present accurate information concerning specific defects that can be overcome in all the major peripheral nerves of the body. The extent of the defect will be correlated with the type and length of incision to be employed in overcoming the defect. Secondly, it is necessary to discuss the principles that must be followed in any operation in which a gap is to be made up between nerve ends. By nerve defect (or gap) we refer to the final defect measured, with the extremity extended, between the proximal and distal stumps after they have been prepared for suture by excision of neuroma from the central end and pseudo-neuroma from the distal segment.

During World War II at the neurosurgical center located at Tilton General Hospital and later at Thomas M. England General Hospital, the writers

collected information on the defects encountered in 625 peripheral nerve sutures performed from April, 1943, to July, 1945. In each instance the defect was measured at operation with the extremity extended and the severed nerve ends as they were found. Then the defect was measured after the two ends of the nerve had been completely mobilized throughout the incision, the ends prepared for suture by excision of neuroma and pseudo-neuroma, and the joints properly positioned. A third measurement was the defect that could have been overcome by utilizing complete mobilization and positioning with the nerve ends sutured under tension, this being the maximum possible defect which could be repaired with any given incision. The figures stated in the accompanying tables are obtained by averaging the defects which have been overcome in many patients and, therefore, it should be pointed out that these figures may vary from one to 1.5 centimeters in certain instances. There are several reasons for this—one is the difference in length of extremities and, more important, is the fact that the relaxation in the proximal and distal ends varies according to the degree of trauma, the severity of the original infection, and the length of time that has elapsed between the injury and the repair.

Nerve defects are overcome by three means: (1) Mobilization of the proximal and distal ends of the trunk; (2) Positioning of the joints of the extremity (usually by flexion); (3) Transposition of the nerve to a new anatomical location. Mobilization and positioning are the methods most generally used to provide the length for bridging a defect. It is only in the ulnar nerve that transposition is commonly done to gain additional length.

It is our belief that considerable judgment must be used by the surgeon in deciding what proportion of mobilization or positioning is to be used in overcoming a defect. By mobilization, we mean the complete dissection of the proximal and distal nerve trunks from the enveloping tissues through the length of the incision. This procedure will necessarily interrupt the small blood vessels that enter the nerve in its course through this part of the extremity. Mobilization can be overdone if one makes an excessively long dissection of the nerve when the proper degree of positioning of the joints would have provided part of the length necessary. An equally serious error is made by employing extensive positioning of the joints at the expense of mobilization. Such is apt to result in excessive suture line tension and, when the extremity is extended, irreparable intraneural damage to the nerve occurs for a considerable distance above and below the point of suture which has a profound effect on the amount of recovery that occurs. Therefore, it is obvious that the proper combination of the two methods must be used in every case. No hard and fast rule can be given for accomplishing this purpose, but the simple realization that the two methods must be employed in their proper relation to each other is a fundamental step toward selecting a satisfactory procedure. In general, mobilization should be considered sufficient when the joint to be used is positioned to approximately 50 per cent of its normal range of motion and the suture can be accomplished without tension.

The figures given in the tables under the heading "Usual Defect Which Can Be Repaired with Ease" represent lengths of defects which have been repaired followed by proven recovery of motor function in the involved nerve. The writers personally followed these cases, and have not been satisfied with questionable signs of recovery. The definite return of motor power has been the only acceptable positive sign of successful nerve suture. The return of some types of sensation cannot be considered an infallible sign of a successful

nerve suture with return of function taking place. In the last column in the tables, reference is made to the "Maximum Defect Which Can Be Repaired" with a given incision. This maximum defect has occasionally been made up with proved successful recovery, but more often it represents a hypothetical defect which would have resulted had another few centimeters of nerve been resected in the search to reach normal nerve fibers for approximation. Obviously, this maximum gap will be avoided, if possible, by extending the incision for additional mobilization. At the end of the table for each nerve we have included a statement that represents the greatest possible defect that can be overcome in this nerve by mobilizing the nerve throughout an incision extending the entire length of the extremity and with maximum positioning of the joints. We are quite sure that in the majority of such instances there will be no recovery of function. In a few cases, by employing very careful postoperative extension of the joints we have had recovery

in exceptionally large defects, for example, a 15 cm defect in an ulnar nerve, a 7.5 cm defect in a radial nerve, a 12 cm defect in a median nerve, and a 10.0 cm defect in a sciatic nerve.

RADIAL NERVE

The incision (Fig 1) employed in repairing the radial nerve is usually a posterior one which extends from the quadrilateral space laterally around the arm on to the anterior surface between the brachioradialis muscle and biceps brachii tendon to the elbow. Various portions of this incision can be used for small defects, but usually the entire length of the incision will be necessary to

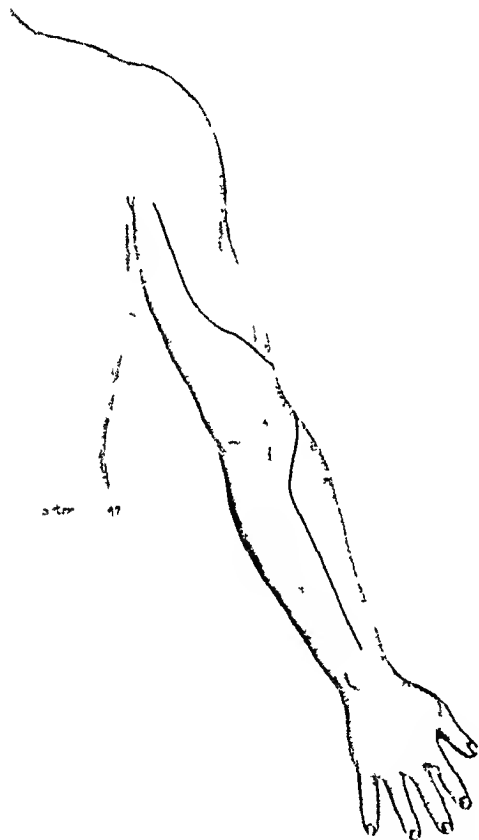


FIG 1—Incision for exposure of the radial nerve in the arm and the dorsal interosseous nerve in the forearm. The portion of the incision for exposure of the nerve in the elbow region is shown on Figure 2.

overcome a sizable defect as well as a minimum of 90 degrees of flexion of the elbow joint. The anterior incision is made from the infraclavicular fossa to the upper third of the arm along the course of the neurovascular bundle, and it is used only in those instances when the nerve is obviously damaged in or above the axilla. Occasionally, both exposures will be necessary if the nerve is damaged in the region of the head or neck of the humerus. It is our opinion that transposition of the radial nerve to the medial side of the arm is of little advantage. This will not gain more than one or, at the very most, two centimeters additional length.

It will be noted in the chart that small defects are made up when the lesions are near the elbow joint. This is due to the fact that injury to this region usually involves the bones of the elbow joint and flexion is, therefore, frequently limited so that the final defect which can be made up is consequently less. Another reason is that the injury is often just proximal to the bifurcation of the radial nerve into the superficial and deep branches and this obviates extensive mobilization of the distal segment. The repair of defects in the deep branch of the radial nerve is essentially the same problem as occurs when the main trunk of the nerve is injured in the elbow region.

Injuries to the dorsal interosseous nerve are usually irreparable because more than two centimeters of nerve substance are almost invariably destroyed when there is an associated fracture of the head and neck of the radius, but occasionally when the nerve is cut by a saber or knife wound, it is possible to repair a defect of one or 1.5 centimeters and suture the nerve ends. The current literature indicating repair of defects in excess of two centimeters in this nerve probably refers to lesions of the deep branch of the radial nerve rather than the dorsal interosseous. The dorsal interosseous nerve referred to

TABLE I—*Radial Nerve*

Information obtained from 79 operations

Site of Lesion	Limits of Incision	Usual Defect Which Can Be Repaired With Ease	Maximum Defect Which Can Be Repaired
Axilla	Supraclavicular region to mid $\frac{1}{3}$ of arm	2.3 cm	2.5 cm
Arm	Posterior axillary fold to upper $\frac{1}{3}$ forearm	6.2 cm	8.0 cm
Elbow region	Mid $\frac{1}{3}$ of arm to mid $\frac{1}{3}$ forearm	3.4 cm	5.0 cm
Forearm (dorsal interosseous nerve)	Elbow to distal $\frac{1}{3}$ of forearm	1.0 cm	1.5 cm
Theoretical maximum defect that can be repaired	Anterior and posterior incisions combined	8.0 cm	10 cm

in this paper is that portion of the deep branch of the radial nerve that begins at the inferior border of the supinator muscle after the deep branch has extended around the neck of the radius and extends distally on the dorsal surface of the interosseous membrane to the middle or distal one-third of the forearm. If for any reason a defect in the dorsal interosseous nerve over 2 centimeters is obvious, tendon transfers are done in an effort to overcome the disability due to the paralysis.

MEDIAN NERVE

The incision (Fig 2) for repair of the median nerve is made from the apex of the axilla along the course of the neurovascular bundle on the medial aspect of the arm to the antecubital fossa and then distally through the middle of the volar surface of the forearm to the wrist. It is only with huge defects that it would ever be necessary to mobilize the nerve throughout the entire length of this theoretical incision. For the average median repair with the injury in the arm, the incision will be from the axilla to the elbow. For an injury in the region of the elbow, the incision will probably extend from mid-arm to mid-forearm. Lesions in the forearm generally require an incision throughout the forearm and possibly into the lower arm. If the lesion is near or at the wrist, the transverse carpal ligament will have to be divided and mobilization of the distal stump carried distally into the thenar region.

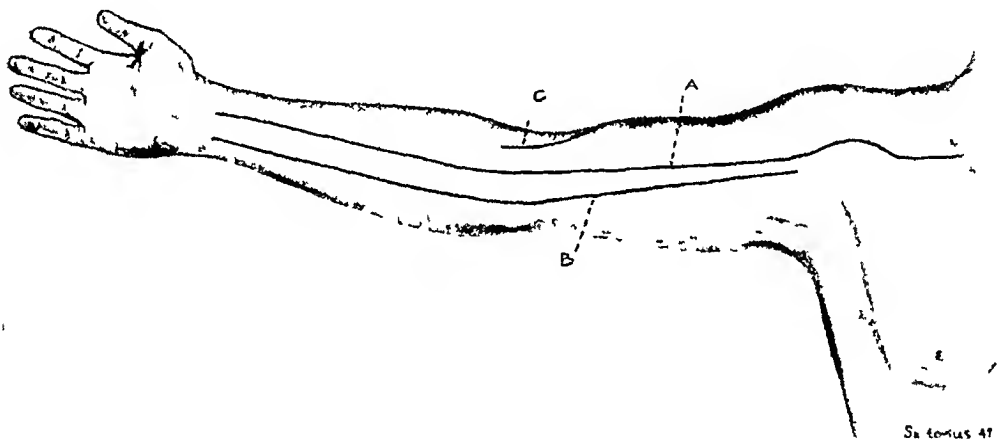


FIG 2—A Incision for exposure of the infraclavicular portion of the brachial plexus, the neurovascular bundle in the arm, and the median nerve in the antecubital fossa and forearm. B Incision for exposure of the ulnar nerve in the arm and forearm. C Distal end of the incision for exposure of the radial nerve in the arm.

Lesions that occur in the upper part of the forearm frequently necessitate transposing the median nerve superficial to the pronator teres. This is accomplished by separating the muscle from its insertion into the radius and at the same time dissecting the motor branches from the main trunk as far proximally as can be accomplished. This allows a virtual subcutaneous transposition of the nerve and will gain from five to six centimeters additional length. Transposition may be used, of course, with any lesion where additional length is needed. Therefore, it is possible by complete dissection of the median nerve from wrist to axilla and transposition subcutaneously to overcome a huge defect in the neighborhood of 16 to 17 centimeters. This implies that complete positioning is also used by flexing the elbow and wrist. Without transposition, an incision throughout the length of the forearm will afford less than five centimeters of mobilization.

ULNAR NERVE

The incision (Fig 2) for repair of the ulnar nerve extends from the axilla along the course of the neurovascular bundle passing anterior to the medial epicondyle of the humerus to the upper forearm. That portion of the incision at the elbow should be about one and a half to two centimeters anterior to the medial epicondyle and it must extend distally to the junction of the middle and upper thirds of the forearm if the ulnar nerve is to be transposed anterior to the elbow joint. In the forearm, the incision extends along the ulnar side of the volar surface to the wrist along the lateral border of the flexor carpi ulnaris muscle and ends slightly to the radial side of the pisiform bone. It will be found that in any defect in the arm of more than

TABLE II—*Median Nerve*

Information obtained from 115 operations

Site of Lesion	Limits of Incision	Usual Defect Which Can Be Repaired With Ease	Maximum Defect Which Can Be Repaired
Arm	Pectoralis major insertion to elbow	6 0 cm	8 5 cm
Elbow region	Mid $\frac{1}{3}$ arm to mid $\frac{1}{3}$ forearm	6 0 cm	7 5 cm
Elbow region	Distal $\frac{1}{3}$ arm to wrist (nerve transposed)	10 0 cm	12 0 cm
Upper forearm	Mid $\frac{1}{3}$ arm to mid $\frac{1}{3}$ forearm	4 5 cm	6 0 cm
Upper forearm	Mid $\frac{1}{3}$ arm to mid $\frac{1}{3}$ forearm (nerve transposed)	5 5 cm	8 0 cm
Mid forearm	Elbow to wrist	4 5 cm	6 5 cm
Mid forearm	Elbow to wrist (nerve transposed)	7 0 cm	9 0 cm
Distal forearm	Mid $\frac{1}{3}$ forearm to wrist	4 0 cm	5 0 cm
Wrist	Distal $\frac{1}{3}$ forearm to palm	1 8 cm	2 5 cm
Theoretical maximum defect that can be repaired	Pectoralis major to wrist (nerve transposed)	12 cm	17 cm

two centimeters or in any defect in the forearm of more than four centimeters, it will be necessary to transpose the ulnar nerve anterior to the elbow joint. We prefer making the incision anterior to the elbow joint, but this is a matter of preference, and it can be handled satisfactorily with a posterior incision. We are certain that when the ulnar nerve is transposed it should never be placed beneath the detached flexor group of muscles as is sometimes advocated. Experience has shown beyond any question that this will frequently prevent regeneration, whereas it will progress quite satisfactorily with the nerve in a subcutaneous position external to the flexor group of muscles. It is important to begin the transposition in about the mid-forearm so that the nerve passes through a hiatus in the deep fascia and gradually assumes an anterior position over the flexor group of muscles rather than having it abruptly enter the new position from a point a centimeter or two below the medial epicondyle of the humerus.

OTHER NERVES OF THE UPPER EXTREMITIES

The musculocutaneous nerve is infrequently injured but the lesion occurred 14 times in this series. The usual defect which can be made up with ease in

TABLE III—*Ulnar Nerve*

Information obtained from 215 operations

Site of Lesion	Limits of Incision	Usual Defect Which Can Be Repaired With Ease	Maximum Defect Which Can Be Repaired
Arm	Axilla to lower $\frac{1}{2}$ arm	2 cm	3 cm
Arm	Axilla to upper $\frac{1}{2}$ forearm (nerve transposed)	6 cm	10 cm
Elbow region	Mid $\frac{1}{2}$ arm to mid $\frac{1}{2}$ forearm (nerve transposed)	5 2 cm	9 cm
Upper forearm	Upper $\frac{1}{2}$ arm to mid $\frac{1}{2}$ forearm (nerve transposed)	4 6 cm	8 cm
Mid forearm	Upper $\frac{1}{2}$ forearm to wrist (not transposed)	3 2 cm	5 cm
Mid forearm	Upper $\frac{1}{2}$ forearm to wrist (nerve transposed)	4 7 cm	7 5 cm
Distal forearm	Distal $\frac{1}{2}$ arm to wrist (not transposed)	3 4 cm	5 0 cm
Distal forearm	Distal $\frac{1}{2}$ arm to wrist (nerve transposed)	6 5 cm	10 cm
Maximum defect which can be repaired	Axilla to wrist (nerve transposed)	12 cm	16 cm

the musculocutaneous nerve is four centimeters or less, although it is possible to make up a defect of five centimeters without too great difficulty. The nerve can be exposed throughout its entire length by an incision from the apex of the axilla along the course of the neurovascular bundle to the mid-arm. The defect is then overcome by flexion of the elbow and marked adduction of the arm. Lesions of the axillary nerve are extremely rare unless as part of a brachial plexus injury. In our experience, repair of this nerve is uniformly unsuccessful but a defect of approximately two centimeters can be bridged.

SCIATIC NERVE

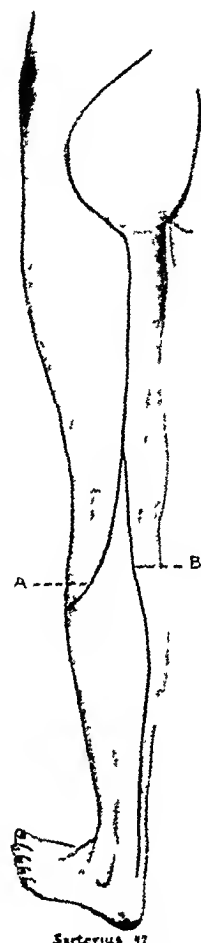
The incision (Fig. 3) for repair of the sciatic nerve extends along the middle of the posterior surface of the thigh, beginning at the gluteal fold and extending distally to the middle of the popliteal space. If the lesion is situated above the gluteal fold, it is necessary to detach the gluteus maximus insertion and a different incision is then employed. This is the so-called Stookey operation. If the buttock is not reflected, the incision will probably extend the entire length of the thigh. By reflecting the buttock, it is possible to suture lesions actually within the sciatic notch or at any point distal to it. It is not

TABLE IV—*Sciatic Nerve*

Information obtained from 53 operations

Site of Lesion	Limits of Incision	Usual Defect Which Can Be Repaired With Ease	Maximum Defect Which Can Be Repaired
Buttock	Buttock to upper $\frac{1}{2}$ leg	8 5 cm	11 0 cm
Buttock	Buttock to mid $\frac{1}{2}$ thigh	6 0 cm	9 0 cm
Thigh	Gluteal fold to knee	6 0 cm	9 0 cm
Maximum defect which can be repaired	Buttock to upper $\frac{1}{2}$ leg	8 5 cm	11 0 cm

always possible to repair a very large defect if the lesion is high under the buttock or within the sciatic notch, because it is impossible to mobilize the central stump to any appreciable extent. In fact, if the lesion is more than a centimeter within the sciatic notch, it probably cannot be repaired at all. In addition, in lesions within the sciatic notch, it is impossible to place sutures on the ventral surface of the nerve, and one has to be content with a suture of approximately two-thirds of the dorsal circumference of the nerve. To obtain the necessary length when the lesion is at the notch or under the buttock, it is often necessary to sacrifice one or more of the distal motor branches, usually the branches to the long head of the biceps femoris muscle. This will always give two to three centimeters additional length to aid in overcoming the gap. In spite of the tremendous additional length that flexion of the leg on the thigh will afford, the nerve will sometimes be under such tension that one or two centimeters additional length will be essential, and in order to gain this, hyperextension of the hip is employed. In such instances, it is essential that the patient be put in a spica cast with the hip in the hyperextended position. Maintaining this position during the application of the cast may be quite difficult, but if care is used, one or two centimeters of additional length can always be obtained by this method.



COMMON PERONEAL NERVE

The incision (Fig 3) for repair of the common peroneal nerve is identical to that of the sciatic nerve except that in the popliteal space the incision extends laterally, parallel to the biceps femoris tendon and then courses diagonally across the upper leg at the level of the neck of the fibula anteriorly to the interval between the tibia and fibula. We have had no experience with excision of the head and neck of the fibula to gain length for suture, but it seems probable that some additional length could be obtained by this procedure, perhaps two centimeters. It should be noted that repair of the common peroneal nerve in the thigh is no different from repair of the sciatic nerve in the same part of the thigh except that, if the tibial portion should be intact, a little less length can be made up in the common peroneal because the intact tibial compromises the dissection somewhat. This results from the anatomic

FIG 3—Incision for exposure of the sciatic nerve in the buttock and in the thigh A Distal end of the incision for exposure of the common peroneal nerve in the popliteal space and upper leg B Incision for exposure of the tibial nerve in the popliteal space and in the leg The distal one-third of this incision is placed midway between the internal malleolus and the Achilles' tendon, more medial than indicated in the illustration

structure of the sciatic nerve in that the common peroneal and tibial nerves cannot be separated completely from each other throughout the thigh because of intercommunicating fibers connecting the two portions of the nerve. Injuries in the region of the head and neck of the fibula frequently traumatize the common peroneal nerve just at the point where it branches into the superficial and deep portions, and, not infrequently, there is an associated fracture of the bones in this region. Consequently, the repair may resolve itself into a suture of one central branch to two or even more distal branches of the deep component of the nerve. Repair of the deep branch of the common peroneal nerve is technically quite difficult. The dissection is tedious, the nerve is extremely deep between the tibia and fibula on the interosseous membrane beneath the tibialis anterior and the extensor communis digitorum.

TABLE V—*Common Peroneal Nerve*

Information obtained from 97 operations

Site of Lesion	Limits of Incision	Usual Defect Which Can Be Repaired With Ease	Maximum Defect Which Can Be Repaired
(Proximal to the distal $\frac{1}{3}$ of thigh defects are the same as the sciatic nerve)			
Distal $\frac{1}{3}$ thigh and popliteal region to neck of fibula	Gluteal fold to neck of fibula	6.4 cm	8.1 cm
Leg (distal to neck of fibula) Superficial branch	Popliteal space to mid $\frac{1}{3}$ of leg	1.5 cm	2.5 cm
Leg (distal to neck of fibula) Deep branch	Popliteal space to mid $\frac{1}{3}$ of leg	1.0 cm	1.5 cm
Maximum defect which can be repaired	Buttock to upper $\frac{1}{3}$ leg	8.5 cm	11.0 cm

muscles, and suture is difficult even if the nerve ends are near approximation because the nerve is small. If there is a defect of any significant size the nerve cannot be repaired. Rarely is it possible to bridge a defect as great as 1.5 centimeters. The dissection of the superficial peroneal branch after it extends distal to the neck of the fibula is not difficult, but again only a small defect can be repaired—at most 2.5 centimeters.

TIBIAL NERVE

Incision (Fig. 3) for repair of the tibial nerve in the popliteal space or in the lower thigh is the same as for repair of the sciatic nerve. Less defect can be made up in repair of this nerve in the thigh than in the sciatic nerve because it is necessary to separate extensively the tibial from the common peroneal component. This is not advisable if it can be avoided because of the intercommunicating fibers that will be damaged, and disrupting the epineurium on half the circumference of the nerve adds to the technical difficulty in accurately suturing the ends. In the popliteal space less defect can be made up in the tibial nerve than in the common peroneal nerve because its course is more direct and it is more deeply situated so that flexion will not provide the additional length that will be gained in the longer and more superficial common

peroneal nerve To repair the tibial nerve in the leg, an incision is made beginning at the ankle midway between the medial malleolus and the Achilles' tendon extending proximally in a gradual curve to the midline of the leg over the belly of the calf muscles and gradually back to the midline of the popliteal space In the leg if the defect is greater than five centimeters it is necessary to carry out a very extensive dissection which involves detachment of the soleus and gastrocnemius muscles from the posterior surface of the tibia up to the popliteal space, and retracting the entire muscle mass laterally This exposes the nerve which is deeply situated in the center of the calf By this procedure a very large defect can be repaired if the incision is extended from the

TABLE VI—*Tibial Nerve*

Information obtained from 52 operations

Site of Lesion	Limits of Incision	Usual Defect Which Can Be Repaired With Ease	Maximum Defect Which Can Be Repaired
(Proximal to the distal $\frac{1}{3}$ of thigh defects are the same as the sciatic nerve)			
Lower thigh	Gluteal fold to mid $\frac{1}{3}$ leg	5.2 cm	6 cm
Popliteal region	Gluteal fold to mid $\frac{1}{3}$ leg	4.5 cm	9 cm
Leg	Upper $\frac{1}{3}$ leg to ankle	3.0 cm	5.0 cm
Leg	Distal $\frac{1}{3}$ thigh to ankle	8.0 cm	11.0 cm
Malleolus	Mid $\frac{1}{3}$ leg to malleolus	1.5 cm	2.5 cm
Maximum defect which can be repaired	Buttock to upper $\frac{1}{3}$ leg	8.5 cm	11.0 cm
	Mid $\frac{1}{3}$ thigh to ankle	9.0 cm	12.0 cm

malleolus through the popliteal space into the lower thigh, as much as 11 or perhaps even 12 centimeters can be made up by this maneuver It is rare, however, that a defect in excess of six or seven centimeters is encountered in this nerve In lesions of the medial and lateral plantar nerves near or below the internal malleolus, only small defects, one or two centimeters in size, can be repaired Flexion of the knee joint in the extensive dissection supplies considerable additional length not gained by mobilization alone, while plantar flexion and inversion of the foot accomplish very little in bridging defects over one centimeter long

SUMMARY

- 1 Accurate data on the defects that can be bridged in all the major peripheral nerves of the body are presented
- 2 The fundamental technical methods employed in overcoming nerve defects are discussed
- 3 Practical considerations in repair of a defect of each major nerve are suggested
- 4 Summaries are presented for each nerve in accompanying tables

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MYXOMA, THE TUMOR OF PRIMITIVE MESENCHYME*

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TUMORS OF A MUCOID or myxoid habit resembling mesenchyme are not too uncommon. In a recent study of soft part sarcomas they stood in third place among sixteen named varieties, being surpassed only by fibrosarcoma and liposarcoma (Stout, 1947). Yet the literature contains very little accurate information about them as an entire group. There are several reasons for this. In the first place, there are a number of tumor forms which sometimes are composed in part of myxoid tissue such as liposarcoma, fibrosarcoma, chondrosarcoma, and mesenchymoma. Such tumors sometimes have "myxo-" included as part of the name and there has been a tendency to consider them as variants of the myxoma. This is certainly an error, for clinically they behave like tumors composed of the dominant tissue and should be designated by that name. Further, there has been a tendency on the part of some to use both the terms myxosarcoma and myxoma. This also is probably unwise, for myxomas do not metastasize and there is no way to anticipate differences in their growth energy from their histopathology. Still another difficulty arises because of the resemblance of ganglions of the tendon-sheaths and skin to myxomas. Finally, there are the peculiar primary myxoid tumors of the heart, about which so many papers have been published denying and affirming their neoplastic nature, their degree of malignancy and their relationship to primary heart muscle tumors. It seems probable that among them there are examples of undifferentiated mesenchymal proliferations both granulomatous and neoplastic. Of the latter some are undifferentiated myxomas, some are rhabdomyomas, and some are mixed (Batchelor and Maun, Mahaim, Ravid and Sachs, Anderson and Dmytryk). It must also be pointed out that myxomas of the heart are the only tumors given that name from which metastases have been reported (Fenster). This is so exceptional as to warrant the suspicion that such metastasizing tumors are probably not true myxomas but sarcomas of some other type masquerading as myxoma. For these reasons it is quite difficult to learn accurately from the literature the exact distribution and biological course of this group of tumors.

It seems necessary first to define what shall be understood by the term "myxoma." For the writer, it is a true neoplasm composed of stellate cells set in a loose mucoid stroma through which course very delicate reticulin fibers in various directions. In other words, it closely resembles primitive mesenchyme. This resemblance has been noted by Greco, by Harris, by Hogenauer, by Saturewski and others. The only variation from this is the occasional

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formation of denser areas due to a thickening of the delicate connective tissue fibers and a lessening of the mucoid material. In such areas, because of this increase in density, some of the cells may become spindle shaped, probably as a result of pressure molding, but these areas should not be extensive. One must allow this much variation, since any tumor may undergo some degree of fibrosis. There must be no chondroblasts, lipoblasts, rhabdomyoblasts or any other recognizable differentiated elements. Unlike the progressing ganglions which have a multicentric origin and tend rapidly to form cysts containing hyaluronic acid, the myxoma has a unicentric origin, grows progressively by infiltration and/or expansion and rarely reaches a great size. It is probable that the mucoid material of the myxoma is hyaluronic acid and not mucus. The fact that when hyaluronidase was added to the thick material obtained from the tumor in Case 1 this material was partly fluidified, would suggest this. According to Meyer there is a relatively large amount of hyaluronic acid in the primitive mesenchyme, which also suggests that the myxoma is a neoplastic reproduction of primitive mesenchyme. Perhaps most important of all, the myxoma does not metastasize and, if it kills, it is because of damage to vital structures produced by infiltrative or expansile growth causing pressure or erosion. As examples of this there may be cited the case of Hogenauer (1933) in which death from asphyxia was caused in a 40-year-old woman by a myxoma of the neck that surrounded the esophagus and completely blocked the trachea by compression, and Rosenberg's (1936) 46-year-old patient with myxoma of the prostate which caused death by filling the pelvis and compressing its structures.

Using this definition, the writer has been able to recognize 49 cases of myxoma recorded in the Laboratory of Surgical Pathology of Columbia University, and after a not too exhaustive search of available literature has found 95 more, exclusive of the heart. More than 100 cases of myxoma involving the heart have been reported.

The anatomic distribution of these cases is shown in Table I.

An examination of this table shows that most of these tumors are found in the heart, the skin, subcutaneous and aponeurotic tissues in certain bones, and the genitourinary system. Myxomas in other situations are rare. The soft part tumors are widely distributed, but many of the bone cases are found in the jaws. In addition to the bones mentioned in the chart, cases are reported in the fibula (Leriche), tibia (Lehmann), ulna (Garavano and Schwjowicz), skull (Brackmann, Inclán and Inclán), jaws (Thiargo Marques, Tholen, Milhon and Parkhill), metatarsal (Copello), periosteum of metatarsal (Marziani) and phalanx of toe (Danielewski and Komza). Other bone cases were described by Bloodgood. In the genitourinary system, the greatest number are found in the urinary bladder, spermatic cord and vulva.

The sex of 46 of our cases is recorded. 25 were female and 21 male. Six patients were Negroes. The age at onset of symptoms is recorded in Table II. From it one can only conclude that the myxoma is a tumor which may make its appearance at any time from birth to old age.

Clinically the tumors in the soft parts which can be examined do not have any very striking characteristics, largely perhaps because most of them are so deep that their myxoid qualities are masked, or, if they are in bone, completely hidden. The largest tumor in the Columbia University group

TABLE I—*Anatomic Distribution of 140+ Myxomas*

	Total	Personal	Lit
Subcutaneous and aponeurotic	32	25*	7
Bone	26	10†	16
Genito-urinary	23	2	21
Skin	22	4	18
Retroperitoneal	5	2	3
Intestine	5	1	4
Nares and sinuses	5	0	5
Muscle	4	1	3
Joint	4	1	3
Pharynx and tonsil	3	0	3
Breast	3	0	3
Orbit and eyelids	4	1	3
Intracranial	1	1	0
Spleen (Tomaneh)	1	0	1
Appendix (Laird and Nolan)	1	0	1
Liver (Zuidema and Seldam)	1	0	1
Parotid gland (Vrzensin)	1	0	1
Carotid body (Bertola)	1	0	1
Ear (auricle) (Hand and O Connor)	1	0	1
Heart	many	1	many
	143+	49	95+

Lower ext 7 upper ext 6 head 5 back 5 neck 1 inguinal 1
† Mandible 5 maxilla 3 clavicle 1 metatarsal 1

measured 30 x 10 cm and was in the leg of a 68-year-old male. It had been excised when smaller, after 19 months of growth. Recurrence appeared after one month, and in four more it had attained the size recorded. The patient refused amputation and could not be traced after leaving the clinic. The largest authentic myxoma recorded was reported by Jonas (1937). After

TABLE II—*Age at Onset of Symptoms of 99 Cases of Myxoma*

0-9	10-19	20-29	30-39	40-49	50-59	60-69	70
17	11	11	10	25	11	13	1

three years of abdominal enlargement a tumor measuring 32 x 26 x 24 cm and weighing 5426 gm was removed from the retroperitoneal region of a 36-year-old woman. It originated seemingly from the parametria and extended upward to both sides of the diaphragm. It was gelatinous with cystic areas, and histologically was a vascular myxoma. No follow-up was reported. A tumor weighing 82 kilos attached to the labium majus, extending up between vagina and rectum and measuring 62 x 63 cm with a circumference of 125 cm was described by Leischner (1930) but this was probably a liposarcoma.

The duration of symptoms (*i e* tumor) before treatment has varied widely from two weeks to 37 years and averaged 4 years. Like many other tumor varieties it is apparent that a myxoma tends to grow very slowly or remain stationary for long periods of time and then may suddenly enlarge rapidly. There is no rule about the relationship of these phases one to the other, rapid growth may come at the beginning or the end of a quiescent period, or may be both preceded and followed by inactivity.

It is of interest to find that both Krogius and Bolognesi have noted the concurrence of myxomas in the soft parts and fibrous lesions in the bones. When myxomas grow in bone, they develop in the marrow, expand the cortex, destroy bone by aseptic pressure necrosis and produce a deformity of the bone which cannot be distinguished roentgenologically from osteitis fibrosa, giant cell tumor or fibrous dysplasia, and, in the case of the jaws, from adamantinoma or paradental epithelial cyst (Fig 5). If, as in Case 5, the tumor springs from the periosteum, there may be no bony deformity (Fig 7). When myxomas grow in or close to the skin, they have a semitranslucent pallid aspect which simulates the appearance of some lymphosarcomas and ganglions of the skin and of an occasional liposarcoma, if invasion brings it close to the epidermis. In this situation the myxoma may be soft and suggest fluctuation (Fuhs, Gross, Jacox and Freedman, Kusnetz, Maynard, Sanchez Carvisa and Bejarano). While many of them are found at the finger tips (Case 2), they have been reported from other parts of the skin surface in both single and multiple form. Almost all of them are relatively small. In the intestine most of them have been pedunculated growths projecting into the lumen and causing intussusception (Case 6, Brachetto-Brian and Latienda, Sullivan and Corcoran, Du Bourguet *et al* Perry and Peters). Most of the genitourinary myxomas have developed in infants from the bladder (Bongiorno, Grynfeldt, Harris, Lazarus and Rosenthal, Meade, and Weiss and Meyer) but Saturski's patient was 33 years old. The trigone was the usual site of origin. Hematuria and obstructive symptoms occurred and usually, although not invariably, growth progressed continuously to a fatal outcome in spite of the most radical attempts at removal. Myxomas have been found in the spermatic cord (Baiocci, Collins and Berdez, Tsuchiya and Shindo), the scrotum (Grimaldi and Bernardi, Loubat and Dareys, Menville), the round ligament (Peltier de Queiroz), the vulva (Abdanski and Landsberg, Menini) and the ovary (Kikuti and Minakawa). Orbital and eyelid myxoma cases have been reported by Lamb, Quintana and by Town, mammary gland myxomas by Marano, Posgay and by Sammartino and there are several reports of myxomas in the upper respiratory passages. The larynx cases are all simply myxomatous polyps and the nasopharyngeal cases either polyps or the fibroangiomas of adolescents. Fuste and Mena Serra's tumor of the maxillary sinus may be a true myxoma and the same may be said of Richter's and of Shiroto's tumors of the antrum.

The treatment of most of these patients has been by surgical excision. Radiation therapy, whether by radium or roentgen-ray, has generally been

either entirely or partly unsuccessful as, for example, in Tomanek's patient who had a myxoma of the spleen reduced to one-half its original volume with external treatment by radium, and in Puente Duany and Paultre's tumor of the thigh treated by roentgen-ray. However, Jacob and Freedman, by using caustic doses of roentgen-ray for the small finger lesions, reported that they effected cures. Sometimes the operative removal has been adequate but too frequently it has been inadequate, as evidenced by many examples of recurrence. The following examples are illustrative. Dixon and Vadheim removed a grapefruit sized myxoma from the region of the kidney. In spite of postoperative roentgen-ray treatment, a recurrent mass adherent to the hepatic flexure necessitated a partial colectomy for its removal 7½ years later. Hand and O'Connor's patient had several recurrences involving the external ear, which finally resulted in its loss after 4½ years. Trabucco described a myxoma of the lateral neck region which recurred eight times in 35 years. One of the patients in the group here reported, a man 65 years old, had eight operations for the excision of recurring myxoma of the lateral neck region lasting over a period of 36 years. The results obtained can only be indicated because the follow-up data at hand are inadequate. They are shown in Table III.

TABLE III—*Results of Treatment of 27 Followed Cases of Myxoma Recorded in the Laboratory of Surgical Pathology of Columbia University*

Alive without tumor—over five years	5*
under five years	9
Alive with tumor —over five years	3**
under five years	7
Died —following operation	1
because of tumor	1
of intercurrent disease with tumor persisting	1
Total	27

* Mandible 5 and 23 years maxilla 5½ years arm 6½ years thumb 17 years

** Mandible 9 years leg 16 years lateral neck 36 years

An examination of Table III shows the inadequacy of many of the operations for removal of myxomas. In some instances this may not have fatal results because these tumors do not metastasize and the recurrences in non-essential parts of the body may only be a source of annoyance and discomfort. But sometimes the recurrences may cause death, for instance, if the tumor is in the bladder or retroperitoneal region or at the base of the skull where it is impossible to remove all of its extensions and where persistence of growth can interfere with vital functions. The writer has long been of the opinion that the only proper way to deal with the various tumors derived from mesenchyme is to biopsy them before undertaking treatment. When study of the paraffin section reveals the nature of the growth, a knowledge of the possible behavior of the particular variety of tumor demonstrated will serve as a guide for planning treatment. With most myxomas it is usually necessary to remove a generous amount of apparently uninvolved surrounding tissue to effect eradication.

ILLUSTRATIVE CASES

Case 1.—S P 90331 L G, an 18-year-old colored girl from British Guiana first noticed a lump about the size of a marble in her right arm, 3 years before admission. Her mother said it had been present since birth. Two months ago it caused some mild discomfort. A deeply seated mass which made a visible lump was found on examination in the region of the insertion of the right pectoralis major muscle into the humerus. It was firm, not tender and was movable (Fig 1). The Kline test was negative. The bone was not involved.

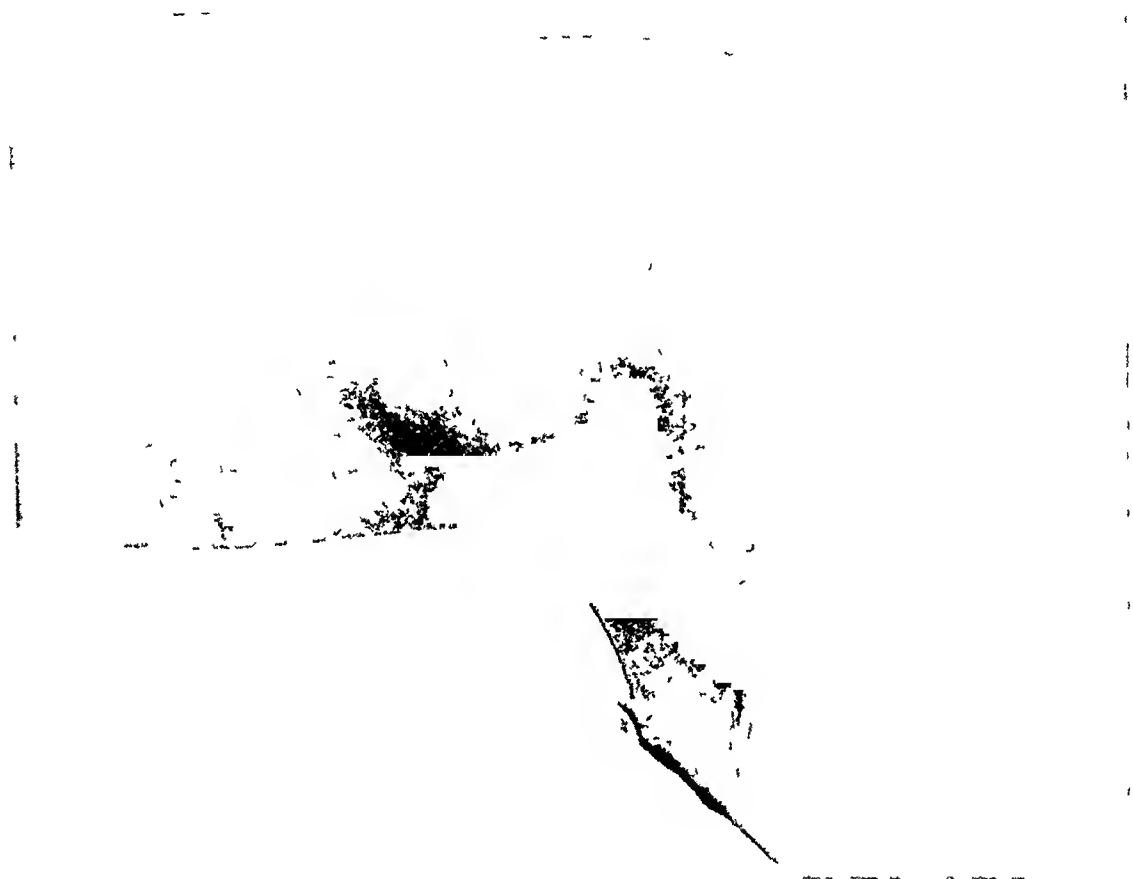


FIG 1—Case 1 Myxoma of the arm

At operation 7/29/44, the tumor appeared encapsulated and lay in the tendon of the pectoralis major muscle near its insertion into the humerus and in the adjacent fascia. The periosteum was not involved. The tumor was first carefully exposed and a biopsy was taken. It was mucoid in character and a quick frozen section was diagnosed myxoma. A second incision was then made through which the first wound, the tumor and the tissues surrounding it were removed in one block without again exposing the tumor. This necessitated removal of a portion of the tendon of the pectoralis major muscle and some of the surrounding fascia. There was no recurrence or interference with function when the patient was last seen 3/25/47, 2 years and 8 months after operation.

Gross examination of the tumor showed that it was apparently encapsulated, measured 4 cm in diameter and on section its consistency was somewhat fibrous, sticky with mucoid and had the color of weak lemonade. The microscopic picture shows a loose-textured tissue of tangled reticulin fibers, somewhat thicker than in other myxomas, separated by clear spaces containing mucoid and set at intervals with stellate cells. The capsule was not invaded by the tumor (Fig 2).

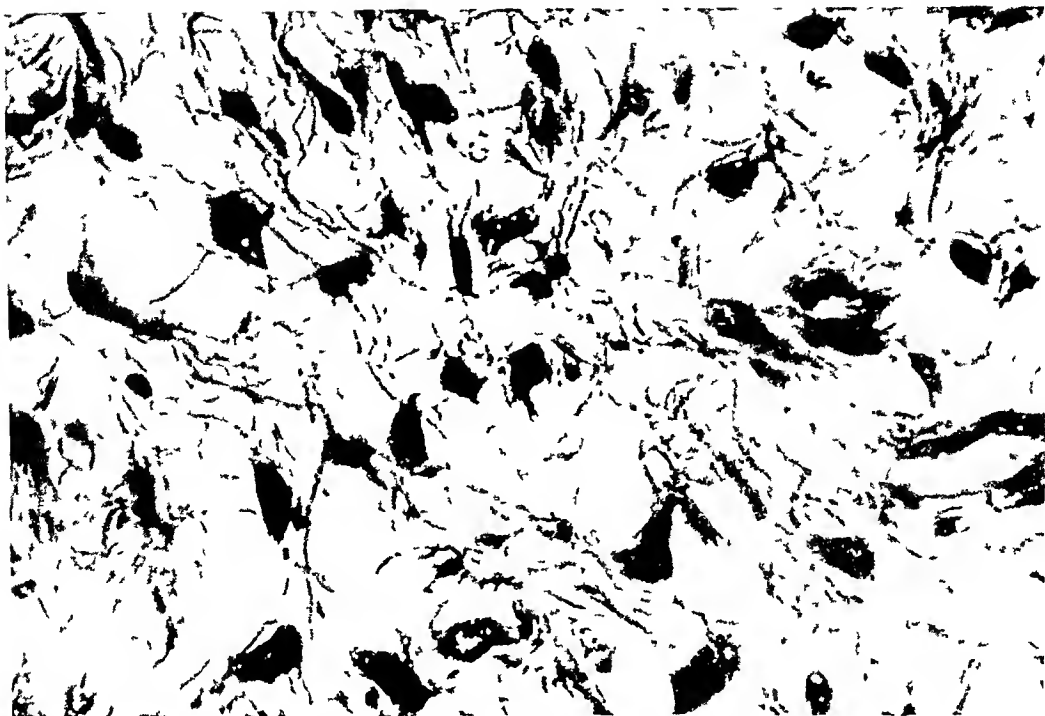


FIG 2—Case 1 Photomicrograph of the tumor



FIG 3—Case 2 Myxoma of the finger tip

the graft had taken and all sutures were removed. He did not return to the Clinic for further observation.

The specimen removed measured $1.9 \times 1.2 \times 1$ cm and two-thirds of its surface was covered by epidermis. On section it showed a glistening translucent mucoid surface. Microscopic examination showed an encapsulated growth lying in the skin, elevating the epidermis and composed of a very loose-textured tumor with fine tangled reticulum fibers, abundant mucoid material and widely spaced stellate cells (Fig 4).

Case 3—S P 26923 M P, a 13-year-old school girl of Italian parentage had had trouble with the lower left first molar tooth for some years. Five weeks before admission she noted swelling of face in this region. One week before admission the loosened molar tooth was extracted. Examination on admission showed that the alveolar process of the left mandible and the bone beneath it were swollen from the second bicuspid

Case 2—S P 94723 H S, a colored male shipping clerk born in Chicago, Ill., 31 years old, came to the Vanderbilt Clinic complaining that 3 years before he had burned the tip of his left index finger and subsequently bit and scratched the area. Some time after this a soft swelling appeared which slowly increased in size. Examination showed a tense fluctuant mass on the lateral volar aspect of the tip of the left index finger. It measured 1 cm in diameter and was called a skin ganglion (Fig 3). August 20, 1945, it was excised intact and the wound was grafted. Nine days later

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through the second molar regions. Roentgen-ray showed an area of rarefaction and expansion of the mandible in this region with displacement of tooth roots. The bony walls of the cavity were thickened by very delicate ridges. The inferior cortex of the body of the mandible appeared very thin (Fig 5).



FIG 4—Case 2 Photomicrograph of the entire tumor. The inset shows details of cells and stroma.

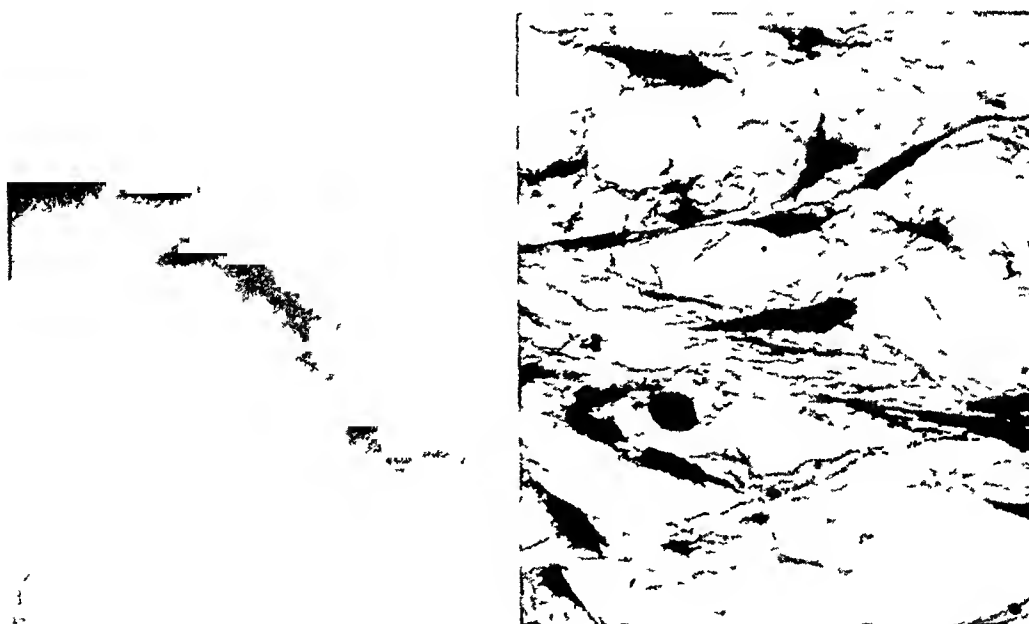


FIG 5—Case 3 Roentgenogram of myxoma of mandible and photomicrograph showing detail of histopathology.

At operation 12/14/21 the cavity was entered through the alveolus and a soft, gelatinous, semitranslucent, pale grayish tumor was encountered and excised piecemeal, together with some bony trabeculae which partly divided the cavity. Five weeks after operation, radium in tubes was placed in the open cavity, and a dose of 400 mgm hours was given. There was no recurrence when the patient was seen 23 years after operation.

Microscopic examination showed a tumor composed of a stroma of tangled delicate reticulum fibers with mucoid material in the intervening spaces and scattered stellate cells (Fig 5)

Case 4—L L, a 26-year-old married American Negress was admitted to the Presbyterian Hospital 6/11/41. Nine months before she noted a small lump in the anterior aspect of the right mandible which gradually increased in size, causing a sense of fullness and occasional shooting pains.

On examination an egg-shaped mass was observed in the mandible extending from the lower left second premolar to the lower right premolar. It pushed the teeth backward



FIG 6—Case 4 Photograph of intraoral appearance of myxoma of mandible

and the lip forward (Fig 6). June 12, 1941, the mandible was resected between these two points.

On gross examination the cortical bone was exceedingly thin anteriorly and the teeth loosened. The tumor inside the bone was homogeneous, reddish gray and translucent. It occupied almost all of the bone resected and came very close to the lines of resection. October 3, 1946, five years and 4 months later there was no recurrence.

Microscopically the tumor was a characteristic myxoma composed of stellate cells set in a loose mucoid stroma with delicate reticulum fibers in it. Occasional bony trabeculae were noted throughout the tumor.

Case 5—S P 85510 L L, British West Indies Negro 50 years old. For the past 15 years the patient had had a growth attached to the left clavicle which appeared without any known cause and remained stationary until 2 years ago when it increased slowly in size but was symptomless.

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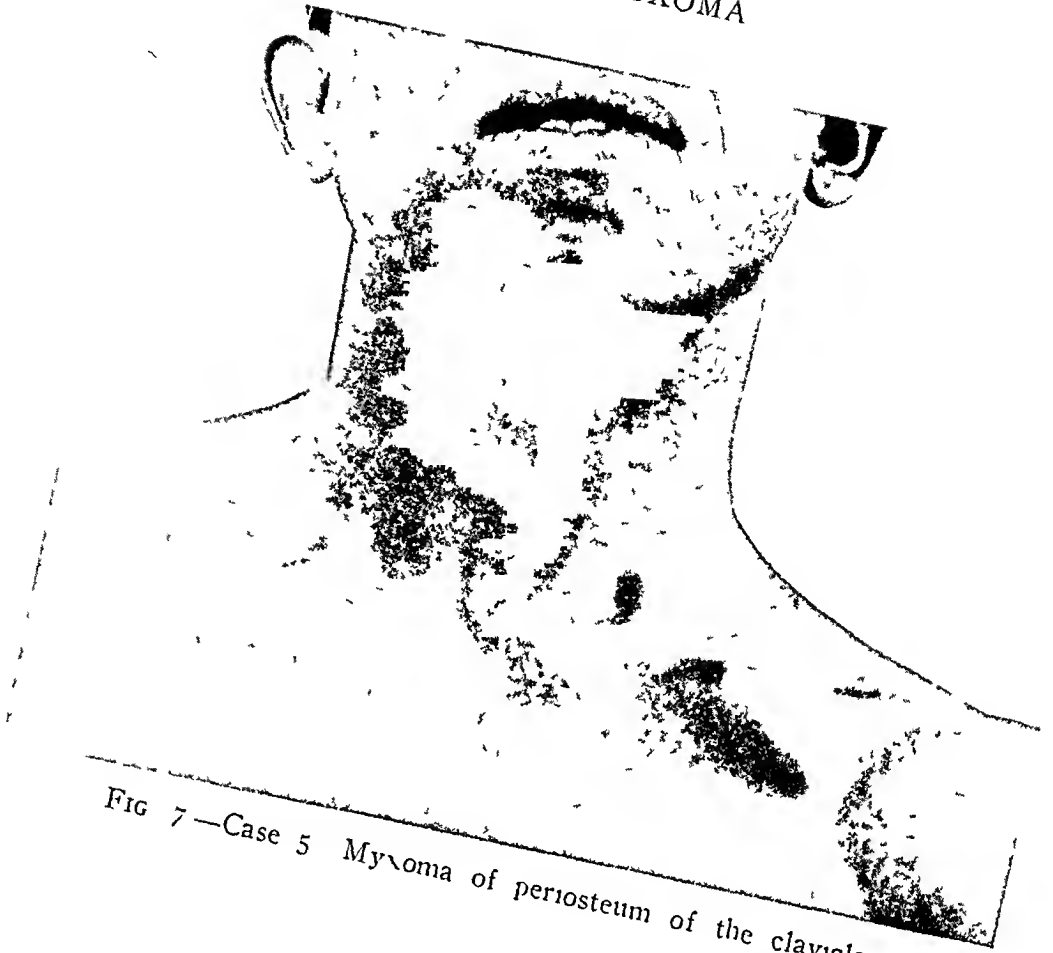


FIG 7—Case 5 Myxoma of periosteum of the clavicle

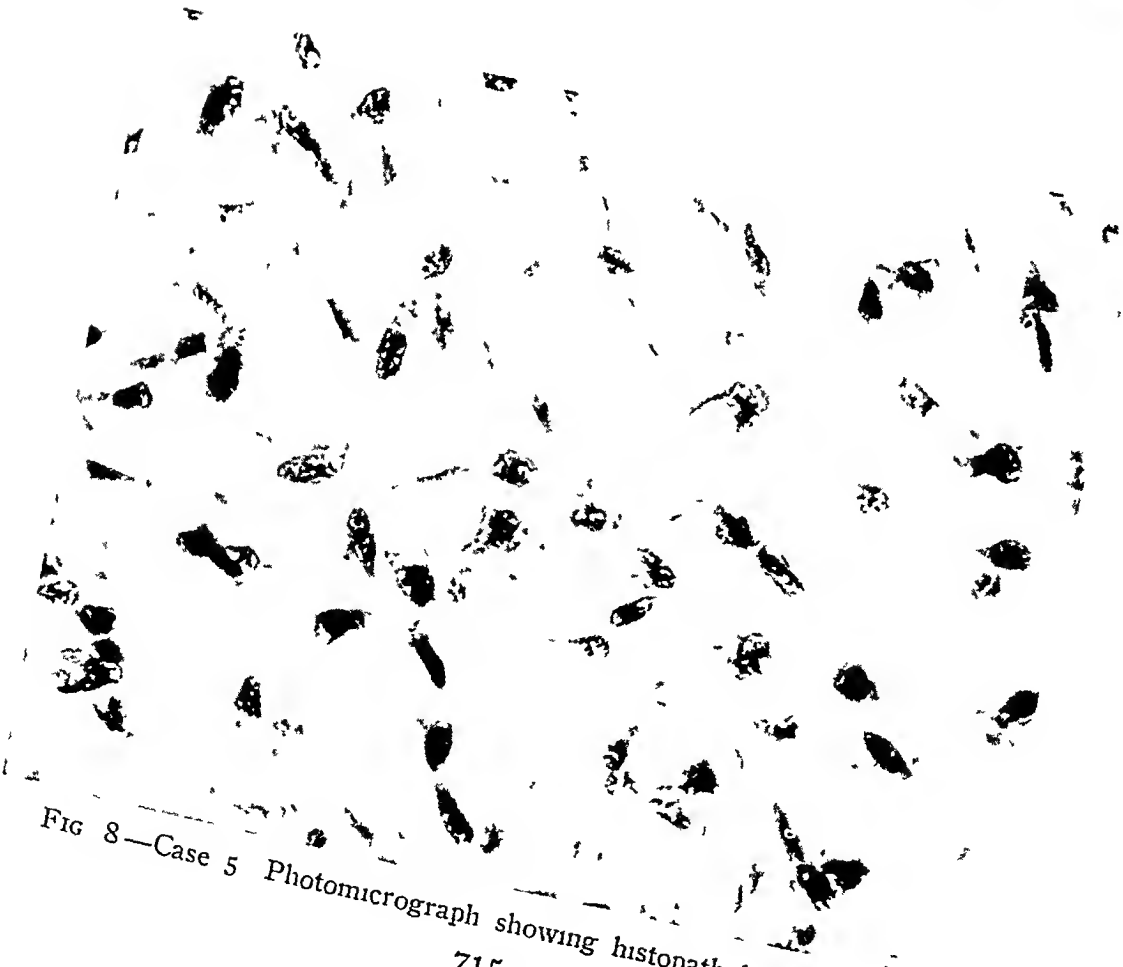


FIG 8—Case 5 Photomicrograph showing histopathology of tumor

On examination there was found an elastic lobulated tumor attached to the middle and inner thirds of the left clavicle. It measured $8 \times 5 \times 2$ cm. Roentgen ray showed no bony lesion of the clavicle (Fig 7).

Operation 4/26/43. The tumor was ovoid, lobulated and had a gelatinous spongy consistency. It was apparently encapsulated and firmly fixed to the periosteum of the clavicle, which was excised with the tumor together with some of the cortex which appeared unaffected. Fifty months after operation there was no evidence of recurrence.

The nodular mass measured $58 \times 33 \times 32$ mm and had a small fragment of the cortex of the clavicle attached to it. It appeared semitranslucent, and when cut a clear colorless stringy mucoid material escaped. Some of this was investigated by Dr Karl Meyer who added to it a little hyaluronidase. This partly liquified the thick material which suggests but does not prove that it was hyaluronic acid.

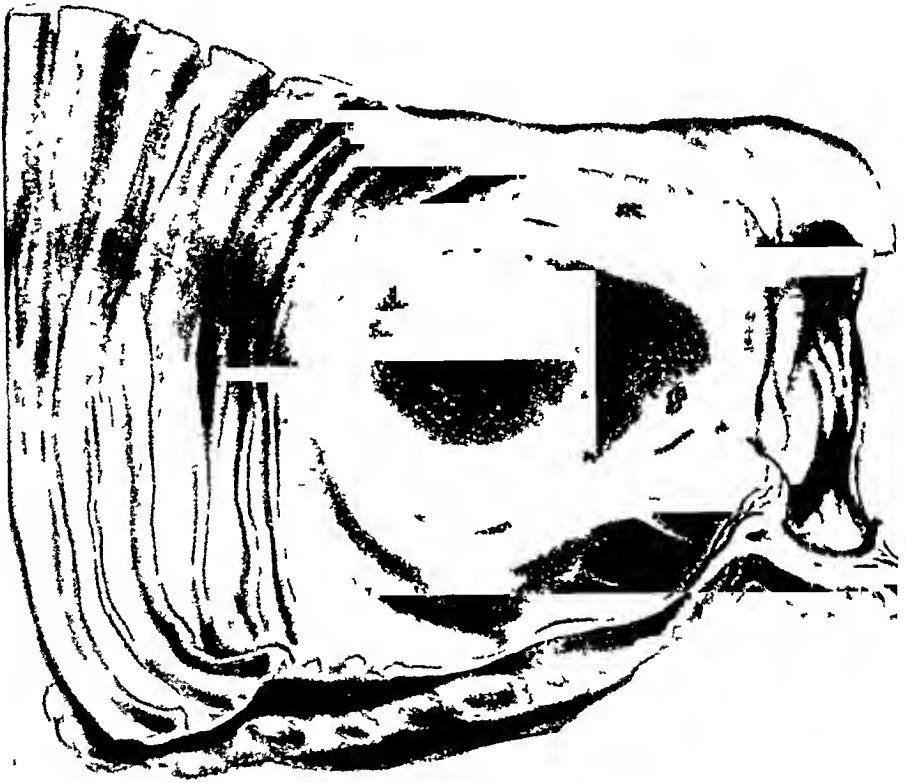


FIG 9—Case 6 Myxoma of the ileum

Microscopic examination showed a very loose textured tumor composed of stellate cells set at wide intervals with mucoid material and a very fine meshwork of reticulin fibers. No lipoblasts were seen. The bone was not invaded (Fig 8). The tumor was explanted *in vitro* by Dr Margaret R Murray. Most of the fragments did not grow at all. Three formed a few stellate cells resembling those found in the tumor.

Case 6—S. P. 22376 (5394). H. S. A married American housewife 68 years old. For 6 weeks before admission she had suffered from intermittent pains in the umbilical region with vomiting, constipation and distention. Physical examination on admission was unrewarding except for distention. A flat plate of the abdomen showed obstruction in the small intestine. At operation 2/15/19 an intussusception was found in the ileum due to the presence of a pedunculated tumor projecting into the lumen. After easy

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reduction 12 cm of the ileum was resected with end-to-end anastomosis. The patient made a good recovery and was symptom free one month later.

Examination of the specimen showed a pedunculated 4.5 x 3.5 cm smooth tumor which was moderately firm and apparently sprang from the submucosa (Fig 9). Sections showed an ulcerated surface covered with granulation and scar tissue which covered the tumor. The latter was composed of stellate cells set in the usual loose textured stroma containing mucoid material and exceedingly delicate reticulin fibers. The tumor appeared well vascularized (Fig 10).

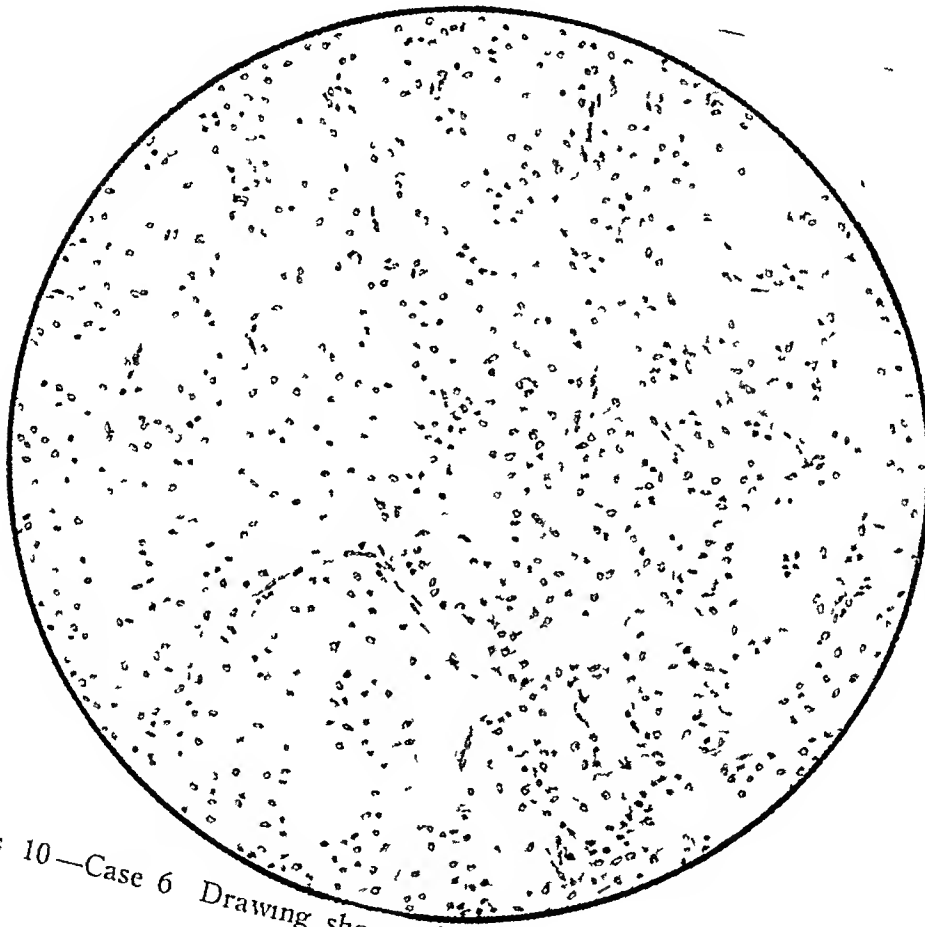


FIG 10—Case 6 Drawing showing histopathology of tumor

SUMMARY

The myxoma is a tumor of mesenchymal origin which reproduces with some degree of accuracy the appearance of primitive mesenchyme. It is made up of a loose textured slimy tissue composed of stellate cells set in a stroma of exceedingly delicate reticulin fibers and a mucoid substance which is probably hyaluronic acid. Rarely portions of it may become denser and resemble fibrosarcoma but no other metaplastic changes occur. The tumor generally infiltrates surrounding tissues to some degree. It is found equally in both sexes at all ages and in many tissues but most frequently in the heart, the skin and soft parts, the bones and the genitourinary system. In the skin the fingers are most frequently involved, a majority of the bone cases are found in the jaws and most of the genitourinary cases develop in the bladder.

The tumors grow at different rates of speed, but usually there are long periods of inactivity which may precede or follow shorter periods of rapid growth. Many never attain a very large size but a tumor weighing over 5 kilos has been described. Metastases have never been reported except from myxoma of the heart and it is possible that this was not a simple myxoma. In any event, their possibility does not have to be considered in treatment. Since the tumors infiltrate, close excision has frequently been followed by recurrence. If this takes place in some region where vital structures can be affected, such as the bladder and retroperitoneal region, a fatal outcome may be the result. The importance of biopsy before treatment in all tumors of mesodermal origin is stressed.

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RAYNAUD'S PHENOMENON AND ATYPICAL CAUSALGIA, THE ROLE OF SYMPATHECTOMY

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IT IS WELL to recognize that the employment of sympathectomy has been somewhat emphatic, since Alexander,¹ in 1899, first performed a cervical sympathectomy for epilepsy. It is only by the gradual accumulation of experience that the procedure has begun to rest on a firm foundation. Realizing that there is an obvious controversy as to its efficacy in many conditions, such as Buerger's disease and hypertension, it is desired to discuss only its use in cases where there is a marked vasospastic element present, without organic obliteration of vascular channels. This report is concerned with the role of sympathectomy in Raynaud's phenomenon and atypical causalgic states. In these, cold sensitivity is a major manifestation.

Since vasoconstriction is one function of the autonomic nervous system, mediated through the sympathetic fibers, one method of study of vasospasm is based upon the interruption of these pathways by various means. One suspects the presence of vasospasm upon the appearance of the following signs and symptoms:

- 1 Hyperhidrosis
- 2 Coolness
- 3 Cyanosis
- 4 Cold sensitivity
- 5 Color changes

Although it is obvious that the mechanism of peripheral vasoconstriction can be humoral as well as neurogenic, it is felt that the latter mechanism is more important. It has, therefore, been considered advisable to test the degree of neurogenic vasospasm by a direct objective method—namely, block of the regional sympathetic ganglia with procaine. For the upper extremity, block of the stellate ganglion by the anterior route with 10 cc of $\frac{1}{2}$ per cent procaine is done, as this method is easily performed and taught, and the objective manifestations of Horner's syndrome³ are unequivocal as to the success of the block. A comparison of the method of posterior block in the region of T2 and T3 with this method presents nothing of importance to recommend the former over the latter, in addition, it is much more difficult to perform, and as hazardous because of the danger of the occurrence of pneumothorax. In the lower extremity, I use a single injection of 30 cc of $\frac{1}{2}$ per cent procaine with a 22 or 20 gauge needle 7 inches long, at a 40° angle to the sagittal plane, in the region of L2 or L3. This method is almost uniformly successful, and not nearly so painful as the three or four needle technic of paravertebral block. Skin temperature determinations, as well as clinical observations, are made under standard conditions of temperature and humidity routinely before and after sympathetic ganglion block.

Although surface temperatures do not accurately reflect the vascular status of the deeper structures,⁴ it should be recognized that this distinction is not nearly so important in vasospastic conditions as in obliterative organic diseases, such as Buerger's disease and arteriosclerosis. This has proved to be a helpful objective determination, when correlated with clinical observations of the extremity made before and after block to note improvement in color, and, equally important, amelioration of the major complaint of the patient. Oscillometric determinations have proved no more advantageous than clinical observation of the peripheral pulses in the consideration of the status of the peripheral vascular condition, particularly in primary vasospastic disorders. This has been the experience of others.⁵ Other methods of undoubted value in diagnosis and evaluation of peripheral vascular disease are plethysmography and capillary microscopy.

The following types of cases representing various degrees of primary vasospasm have been seen and treated:

	Total No	Seen No	Operated On	Preganglionic Sympathectomies
Raynaud's Phenomenon	20	5 (25%)	9 cervicodorsal	
Atypical Causalgia	6	6	(1 cervicodorsal (5 lumbar	
Cold Sensitivity and pain after ligation of main vascular channels (femoral)	2	2	2 lumbar	

In all of these cases, the primary condition was one of vasospasm rather than organic obliteration of the major vascular channels and their tributaries. Exception may be taken to this in the third group, where ligation of the main vessels, the femoral artery and vein, had been done, but, in effect, there was no evidence of organic obliteration of the vascular tree distal to the ligation, as is seen in obliterative vascular disease.

In considering the cases amenable to sympathectomy, one is impressed by a common feature which seems predominant, and that is sensitivity to even *moderate cold*, with marked discomfort and cyanosis. In a sampling of a diverse group of 31 cervicodorsal and lumbar sympathectomies done, all but six (80 per cent) presented this as a primary manifestation. Most presented this as an initial complaint. In practically every instance, the objective manifestations became prominent on exposure to cold. The cold did not have to be severe. This was particularly true of the patients with Raynaud's disease, in which the typical symmetrical triphasic color changes could be best produced in a cool environment rather than by immersion of their hands in ice water.

A total of 20 cases of rather severe manifestations of Raynaud's syndrome were originally seen, and from these five (25 per cent) were selected for sympathectomy. All these cases occurred in men. It is well to emphasize that, although the incidence ratio of women to men is 5:1, and a diagnosis

of Raynaud's disease in men should be viewed with suspicion, the disease is by no means limited to women. Evidence to this effect is given by the report of Hines and Christensen⁶ in which 198 (23 per cent) of 847 cases seen were men. It is an error to teach that the disease rarely occurs in men. The cases concerned in this report, conform to the criteria of Allen and Brown⁷ which are (1) Episodes of Raynaud's phenomenon excited by cold or emotion, (2) bilaterality of the phenomenon, (3) absent or minimal cutaneous gangrene, (4) absence of any primary causal disease, and (5) a history of symptoms being noticed for two years or longer. All presented bilateral, symmetrical, upper extremity triphasic vasospastic phenomena on exposure to cold, and showed no evidence of any other causal condition. Two of the patients were Negroes (10 per cent). The men varied in age from 23 to 42 years. The duration of symptoms varied from two to 15 years, with one individual stating that he had noticed blanching of his fingers on exposure to cold since childhood. All had involvement of both upper extremities, and four (25 per cent) had additional involvement of the lower extremities. There were no cases of simultaneous involvement of all four extremities as an initial manifestation. The duration of the disease did not seem to determine its severity, since some were rapidly progressive. Exposure to cold was the greatest initiating factor, and the critical temperature was variously reported as 57° to 60° F, at which point the vasoconstrictor phenomena would be incited.

The physical findings were minimal, although one case showed early sclerodermatous changes in the digits, and some cases presented rounded finger nails and some atrophy of the finger pads. All demonstrated adequate peripheral arterial pulsations with no gross evidence of arterial insufficiency. Careful evaluation of psychogenic factors was done. It is imperative to do this since Mufson⁸ emphasizes the psychosomatic disturbance as the mechanism of Raynaud's disease, and successfully treated six cases, by eliminating these factors. Six cases presented marked neuropsychiatric disturbances requiring psychotherapy, and these were eliminated from any consideration of sympathectomy.

The vasospastic attacks were studied before, during, and after regional sympathetic ganglion block with procaine, utilizing oscillometric and thermocouple determinations before and after block, and before and during exposure to cold environment. In the upper extremity, stellate ganglion block was employed in three, and dorsal sympathetic ganglion block in two of the operative cases, and no particular advantage of one method over the other was noted. For the sake of simplicity, stellate ganglion block has been routinely used to evaluate the other cases. In every instance the resistance to cold exposure increased, and although the local response to cold, as emphasized by Lewis,⁹ still could occur, recovery from the vasospastic manifestation in the blocked extremity was much swifter than the opposite one under identical conditions. It is recognized that there is an active controversy between the supporters of the conception of increased sensitivity of the sympathetic nervous system

(vasomotor theory), as advanced by Raynaud in 1862,¹⁰ and the group favoring the local fault theory of Lewis. All twenty cases were examined and some treated during the more severe manifestations, by sympathetic ganglion block, and it is worthy of note that even the mild cases improved subsequently. Whether the manifestation of Raynaud's phenomenon is one of local fault^{9, 12, 13} or a consequence of more central vasoconstrictor influence¹⁰ is difficult to decide. It is quite reasonable to assume that the manifestations of Raynaud's phenomenon are probably a combination of the two factors. It is interesting to note that Lewis (1936)⁹ recognized preganglionic sympathectomy to be more effective than ganglionectomy, for the relief of vasospasm. Some investigators¹⁴ who support the theory of Lewis, that Raynaud's disease is primarily a local disease of the digital arteries, advocate operation, because paralysis of the vasoconstrictor nerves results in increased caliber of the denervated arteries. Local spasm, which may take place following sympathetic denervation, consequently, should be less damaging since the lumina of the vessels involved are larger. On this basis, nine preganglionic cervico-dorsal sympathectomies were performed upon five of the more severely progressing cases in this group, with satisfactory results in four and partial failure in one. It is to be emphasized that out of a group of 20 such cases, 15 were treated medically with excellent results, and this is the treatment of choice in the milder cases. That the medical treatment of Raynaud's disease is not entirely satisfactory is stressed by Allen, Barker, and Hines¹⁵. They feel that the surgical treatment with sympathectomy still remains the most satisfactory method of treatment in Raynaud's disease. At the Mayo Clinic only progressing lesions are operated upon. Results at the Mayo Clinic in upper extremities in the early or moderately advanced cases are as follows:

- 1 In a small percentage of cases (10-15 per cent) complete and permanent relief has been obtained
- 2 In about half, good but not complete relief has been obtained
- 3 In the remainder there has been no relief, or if relief has resulted, it has persisted for only a few months or a year or two

In the advanced cases, gratifying healing of trophic lesions has been obtained, but relief of the Raynaud's phenomenon has usually not persisted, and eventual advancement of the sclerodermatous changes has not been prevented.

One of the most optimistic reports published, concerning the surgical treatment of Raynaud's disease, is that of White and Smithwick¹⁶ in which 93 upper extremities were denervated for primary vasomotor disorders, with good results in 65 (70 per cent). Shumacker¹⁷ reported 26 sympathectomies on 13 patients with vasospastic diseases. Eight were in patients suffering from the common type of Raynaud's disease, and he felt that the procedure was very beneficial. Other reports have not been enthusiastic. Johnson¹² studied five cases which had sympathectomies for Raynaud's disease. In 17 to 35 days, the circulation, as tested by finger volume pulsations, returned to previous levels, although temperatures remained elevated and the absence

of sweating persisted. He does not favor sympathectomy. Fontaine, Forster, and Stephanini,¹⁸ reporting the late results in three cases, found improvement in two following bilateral splanchnicectomy, upper lumbar sympathectomy, removal of the left adrenal gland, and extirpation of both stellate ganglia. They came to the conclusion that the disease must be associated with the autonomic function of the arterioles and capillaries. They believe that the surgical procedures are done too far away from the seat of the abnormal vasoconstrictor phenomena.

The failure of the surgical treatment of Raynaud's disease in certain cases is usually in the upper extremity, as occurred in one of my cases, and has been attributed to a variety of causes. Although there is remarkable unanimity as to the surgical procedure for lumbar sympathectomy, concerning the extent and location of resection, this is not true in the upper extremity. The crux of the matter appears to be whether the first thoracic nerve contributes sympathetic fibers directly to the stellate ganglion. This point has been raised by the studies of Kuntz¹⁹ and his coworkers,²⁰ who feel, on the basis of animal experimentation and clinical observation, that the first thoracic nerve contributes sympathetic fibers directly to the stellate ganglion and the upper extremity, and following functional reorganization of pathways after preganglionic cervicodorsal sympathectomy, there is frequently failure of the operation. They are of the opinion, that the attempt of Telford²¹ and Smithwick²² to avoid adrenergic sensitization of the vascular musculature in a sympathectomized extremity by the preservation of the first thoracic nerve thus retains these fibers and accounts for failures. The phenomenon of sensitization has been extensively studied by Cannon and his collaborators,²³ and has been investigated particularly in Raynaud's syndrome.²¹ This sensitization is less marked if a preganglionic section is done leaving the ganglion cells with their axons intact. The view taken by Kuntz is supported by the observation of Ray, Hinsey, and Geohegan²⁴ who made observations of the "Distribution of the Sympathetic Nerves to the Pupil and Upper Extremity as Determined by Stimulation of the Anterior Roots in Men." Other factors to be considered are sympathetic nerve regeneration,²⁵ recovery of intrinsic peripheral vascular tone, the role of sympathetic vasodilator pathways, multiple arteriovenous shunts, humoral and metabolic control of the circulation through denervated vessels, abnormal spasm of the peripheral vascular bed, and the possibility that the decentralized ganglion in preganglionic sympathectomy may be the source of vasoconstrictor tonus, and thus not produce a maximal desirable result.²⁷

The preponderance of surgical opinion favors the use of preganglionic sympathectomy, and this is the method that I have utilized in five cases (nine extremities) of Raynaud's phenomenon. The extent of sympathectomy can be easily determined postoperatively by the use of the electrical skin resistance determinations²⁸ or the performance of a sweating test.²⁹ This method has been utilized frequently in the cases being reported in order to ascertain accurately the extent of the sympathectomy. The extent of denerva-

tion is uniform in the upper extremity by employing the method of preganglionic sympathectomy as reported by Smithwick²² The results of sympathectomy in Raynaud's phenomenon in four cases were excellent, but there was a poor result in one case in which the reaction to cold was still severe, although there was a more rapid return to normal after exposure to cold on the sympathectomized than the unsympathectomized side It is felt that a conservative attitude toward the surgical treatment of Raynaud's disease is in order, and that sympathectomy should be employed only in the severe and progressive cases, particularly with early sclerodermatous and ulcerative changes

ATYPICAL CAUSALGIA

There were six cases in this group worthy of consideration, upon whom one cervicodorsal and five lumbar sympathectomies were done Despite enthusiastic reports to the contrary,^{29, 30, 32, 33} I have not been impressed by the results in lesions in the lower extremity associated with edema The cases of true causalgia in which the discomfort is limited to the anatomic distribution of the involved nerve^{31, 34} were excluded One is impressed by the disappearance of many of the painful manifestations, and where the lesion appears to be one principally of vasoconstriction with sensitivity to cold, the response is excellent I have had occasion to see a considerable number of unilateral lymphedemas of the upper extremity with extreme tenderness of the extremity A case which responded dramatically to sympathectomy is as follows

(A S C) A white man, age 26, was exposed to poison oak and developed sufficient cutaneous reaction to require hospitalization After the dermatitis had subsided, he noted his right hand had become stiff, and soon thereafter the fingers became cold, swollen, painful, and tender He received hot soaks, physiotherapy, and whirlpool, as well as contrast baths and massages, but to no avail He was first seen by me three months later with evident pitting edema of the entire hand and fingers, marked mottling of the skin, and trophic changes in the fingernails He experienced considerable pain on exposure to cold, and there was marked tenderness to touch There was no clinical evidence of arterial insufficiency, and the oscillometric readings were equal at the wrist Roentgen-ray films of the hand showed coarsening of the bony trabeculations He was treated unsuccessfully as regards the primary findings, over a prolonged period by elevation, compression, physiotherapy, and active exercises Neuropsychiatric evaluation ruled out a major psychosomatic factor On exposure to *cold*, it was noted that the cyanosis of the skin became greatly exaggerated, and this was well controlled temporarily by stellate sympathetic ganglion block Since the results were only temporary, a cervicodorsal preganglionic sympathectomy was done This resulted in dramatic disappearance of the pain, swelling, and cyanosis There was also gradual improvement and finally disappearance of the stiffness of the fingers Subsequent follow-up, one year later, showed the individual to be completely rehabilitated

This case demonstrates the effectiveness of sympathectomy in ameliorating these atypical causalgic manifestations, following almost insignificant trauma, which if allowed to progress will result in irreparable and almost complete disability Great care must be taken to evaluate any psychosomatic

component which might account for the unilateral lymphedema. This has been observed as a hysterical manifestation, which responded completely and immediately to narcosis and psychotherapy. These cases, however, usually refuse to move their extremity, or allow it to be touched, and have edema of the entire extremity, whereas the reported case presented a localized type of swelling.

Obviously all cases presenting marked vasospastic phenomena do not require sympathectomy. A man (S) aged 30, white, was seen, complaining of coldness and paresthesias of the left lower extremity. A ruptured meniscus had been excised from the left knee four months previously. The left foot was colder than the right, and the peripheral arterial pulsations were slightly diminished on the involved side. The left knee joint appeared satisfactory, and there was no evidence of a primary nerve lesion or thrombosis. Examination of the extremity under standard conditions of temperature (68° F) and humidity (50 per cent) demonstrated that the left foot was 7° cooler than the right. Left lumbar sympathetic ganglion block produced immediate rise of temperature to the extent of 18° F. All the symptoms promptly disappeared, and there has been no recurrence of the condition. This obviously represents a case in which there was a primary vasospastic phenomenon which responded satisfactorily to lumbar sympathetic ganglion block.

The majority of cases followed minor trauma, such as a rather insignificant fracture, minor shrapnel wound, or exposure to environmental trauma (dermatitis). All responded excellently to sympathectomy except those associated with lymphedema of the lower extremity. In two cases in this group, both following fracture of malleoli with prolonged incapacitation before being seen, lumbar sympathectomy was unsuccessful in controlling the edema, and in one case, the pain. The mechanism of this failure must be related to a prolonged state of vasospasm resulting in persistent edema and finally fibrosis with a more or less fixed edema. One patient presented ulceration over the malleolus, which healed following the sympathectomy but the edema did not subside, and both patients are still incapacitated. This points to the fact that these cases must be operated upon early to achieve a satisfactory result. In the late stages, this edema can be controlled by elastic support and elevation.

The mechanism of these sequelae to trauma have been variously explained by the concept of the internuncial pool^{33, 35} and the Lovén reflex^{36, 37}. The concept of the internuncial pool as advanced by Lorente de No³⁵ and adopted by Livingston³³ is based on the premise that a prolonged bombardment of painful impulses sets up a vicious cycle of reflexes spreading through a pool of neuron connections. Because of the summation principle of nerve impulses, there is kept alive within such a pool a constant circling of activity across the synapses involved. The afferent pathway is represented as the sensory nerve fibers traveling in the posterior root. As a consequence, the abolition of pain and vascular spasm and its sequelae results from the interruption of the efferent sympathetic pathways leading from the pool when ganglion block or sympathectomy are employed. The vicious reflex is thus interrupted with beneficial results.

SUMMARY

1 Experiences with ten cervicodorsal and seven lumbar preganglionic sympathectomies in five cases of Raynaud's disease, six cases of atypical causalgia, and two cases of cold sensitivity and pain after ligation of main vascular channels are related

2 The feature of sensitivity to cold, which is a predominant manifestation of vasospastic disorders, is emphasized Eighty per cent of patients requiring sympathectomy, in the author's experience, have presented this as an initial and predominant manifestation Certainly, primary vasospastic conditions should demonstrate this more frequently than any other vascular disease

3 One should not teach that Raynaud's disease rarely occurs in men A group of 20 cases in men with typical manifestations are reviewed

4 The results of preganglionic sympathectomy in Raynaud's disease have been excellent, with a poor result in one case Surgical treatment is desirable only after careful evaluation and only in severe progressive manifestations

5 Sympathectomy for atypical causalgic manifestations has resulted in excellent recovery except where the lesions were associated with edema of long standing in the lower extremity

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MULTIPLE INTUSSUSCEPTIONS, DIRECT AND RETROGRADE, OF TRAUMATIC ORIGIN

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ACUTE INTUSSUSCEPTION commonly is a disease of infancy, however, it may occur at any age and as Miller¹ states it "may develop at any level in the alimentary tract, may be single or multiple, descending or retrograde in type, and have as its basis a wide range of pathologic conditions—" Multiple areas of intussusception, retrograde intussusception, and traumatic intussusception are each a rarity—the combination of these lesions in one case forms the basis for this case report and review of the literature

1 SOLITARY AREAS OF RETROGRADE INTUSSUSCEPTION

Groper² classified retrograde intussusception according to the area of intestine involved. He included (1) jejuno-gastric, (2) enteric, (3) ceco-ileal, and (4) colic intussusception. Bauman³ states that the ratio of retrograde to direct intussusception is 1:200.

A Jejuno-gastric Intussusception Though gastro-enterostomy has been performed since 1881 the first case report of retrograde intussusception of the jejunum into the stomach did not appear until 1917 (Adams, 1935).⁴ Since that time Becker,⁵ Debenham,⁶ Drummond,⁷ and others⁸ have reported cases. Though the etiology remains obscure no cases of traumatic origin have been recorded, and so the entity will not further be considered in this report.

B Enteric Intussusception, Ibos and Legrand-Desmons,⁹ Ladd,¹⁰ Caminiti,¹¹ and many others have reported cases of solitary retrograde enteric intussusception. Homans¹² reported the following interesting case of recurrent retrograde intussusception in an Armenian girl. On initially exploring her the process "was easily reduced," however during her hospital stay she suffered recurring episodes of abdominal distress similar to that experienced prior to surgery. He continues, "She was thin and had a long mesentery so we advised her to fatten up if possible." The patient gained weight but returned in six months with similar complaints and a "pulse not over 90 and a high white count, vomiting very little, the bowels moving every day." She was observed and finally reopened by Doctor Cheever who found "an intussusception in the upper intestines which he was forced to resect." There was no tumor, and both the initial and the recurring intussusceptions were in a retrograde direction. Doctor Homans concluded "There seems to be no possibility of preventing such a strange condition."

Mitchell¹³ reported the successful resection of a gangrenous retrograde ileo-ileal intussusception that was found in a 15-year-old girl. Symptoms of two days' duration preceded the operation, and no tumor or other abnormal local condition was found to explain the lesion.

Recently, Lannon¹⁴ and Culiner reported a retrograde intussusception in a ten-month-old malnourished child. The duodenum, pylorus, and lesser curvature of the stomach were invaginated into the lower esophagus, and death resulted from the obstruction.

C Ceco-Ileal Intussusception Of Groper's² 4 classes of reverse intussusception ceco-ileal apparently is the most rare. Thorek and Lorimer¹⁵ performed a right hemicolectomy for a retrograde ceco-ileal intussusception. Carcinoma of the cecum invaginated into the dilated, chronically obstructed ileum, resection was followed by recovery.

McSwain¹⁶ reported a case of retrograde intussusception of the appendix, so that apparently any of the mobile segments of the gastro-intestinal tract may be the site of this process.

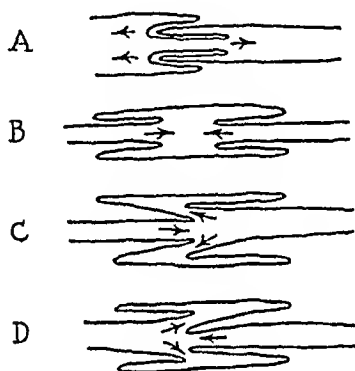
D Colic Intussusception Balfour¹⁷ in 1918 described a retrograde intussusception of the sigmoid colon. A pedunculated malignant papilloma was found at the apex of the intussusciens. Balfour then observed the reformation of the retrograde intussusception as "the tumor was again drawn upward by powerful antiperistaltic contractions of the proximal sigmoid, these contractions extending upward for a distance of from 12 to 14 inches above the site of the tumor." "The process of invagination, begun in this manner, continued until the portion of the bowel containing the tumor was drawn upward and completely engulfed by the proximal segment."

Sussman¹⁸ reported a case in which a lipoma of the splenic flexure was at the apex of a retrograde intussusception. In Lewis'¹⁹ case a 20-inch long pelvic mesocolon was indicted as allowing an extensive sigmoid colon invagination. Schoenfeld²⁰ reported a similar case in a four-month-old child. Fleming²¹ and Lazarus²² have also reported cases of colic retrograde intussusception.

II Multiple Intussusceptions, Direct and Retrograde Multiple areas of intussusception were present in but 12 of the 1000 cases reported by Fitzwilliams,²³ and in but three of Ladd and Gross'¹⁰ 372 cases. Kahle²⁴ in a series of 151 cases reported three instances: one case had six separate enteric and one ileo-cecal mass, and another case in a 21-month-old infant had two separate areas of retrograde intussusception. Gill²⁵ reported that in a 19-month-old female child "six or seven separate ileo-ileal intussusceptions were found close together", the proximal invagination caused complete obstruction and was the only area to show signs of bowel wall congestion. Baron²⁶ found five separate areas of intussusception in a two-year-old boy. These areas averaged 1.3 cm in length and occurred within a 25 cm length of jejunum. Badertscher,²⁷ Le Conte,²⁸ and others^{29-38, incl} have reported single cases, one of Todyo's³⁹ three cases is unique enough to deserve description. A 20-year-old Japanese man with a strangulated inguinal hernia was operated 12 hours after the onset of symptoms. Resection of gangrenous intestine 121 cm above the ileo-cecal valve was performed, and further examination revealed ten separate areas of intussusception in the proximal intestine. Most of these were retrograde and some were superimposed, they were reduced without difficulty, and the patient was discharged on his 16th postoperative day. Twenty-four

days later severe abdominal pain recurred and celiotomy revealed that the lower end of the ileum was strangulated by a band. The band was severed, "at this time multiple intussusceptions were again found in different portions of the small intestine, the uppermost one, 155 cm below the duodeno-jejunal flexure, showing a retrograde, and usual (downward) intussusception at the same time." Todyo continued "Four others were found in a very early stage of development of an invagination, each showing a ring-like fold of the intestinal wall (Fig 1, b). They were all reduced."

III Contiguous Direct and Retrograde Intussusception The varieties of contiguous direct and retrograde intussusception are illustrated in Figure 1.⁴⁰



(A, B, C redrawn from *Intussusception* by P. L. Hipsley M.D.)

FIG 1—Contiguous direct and retrograde intussusception. A Initial direct intussusception (to the right) then passes in a retrograde direction. B Variety found in case herein presented. C The retrograde portion enveloping the direct process. D Similar to C, except for the inclusion by the direct of a portion of the retrograde.

Other variations in the living are possible, however, none were found in the literature. The entity was titled "reverse type intussusception" by Brocq,⁴¹ and "double intussusception" by Mitchell¹² and Hipsley,⁴⁰ both of these terms are loose, and in this report 'contiguous direct and retrograde intussusception' is used collectively to describe the types illustrated in Figure 1. Clubbe⁴³ very briefly mentions a variety of such a combination in a child in whom an ileocecal invagination upon reaching the descending colon appeared—"to form a retrograde movement *en masse* and to be invaginated into the colon higher up the bowel. So, in reduction, pressure first in one direction then in the opposite was necessary." (Fig 1, a)

Catz⁴⁴ reported several cases similar to that described by Power (Fig 1, c) as well as cases in which the direct and retrograde intussusciptions met head on, as in the case reported later in this article, (Fig 1, b).

Buckley⁴⁵ reports the occurrence in a two-year-old child of a direct ileocecal intussusception having then invaginated into an adjacent retrograde intussusception of the transverse colon, Fig 1, c. Redundancy of its mesentery allowed the cecum to be placed in any abdominal quadrant. Wells⁴⁶ reported two similar cases in which the ileocecal intussusciptions had progressed so as to be felt at the anus. A reverse intussusception of the sigmoid colon outside the former mass was found to extend to the splenic area of the mesocolon. D'Arcy Power's⁴⁷ case had, in addition to the envelopment of the direct intussusception by the retrograde process, the entire mass in turn recessed into a second retrograde intussusciptions. He concluded that "The third invagination was

much smaller and was formed after death by a wrinkling of the bowel." The direct process in this case measured three and a half inches and the retrograde two and a half inches. Power adds "I believe it to be an example of an intussusception which is by no means uncommon. It is a particularly deadly variety, first, because distention of the colon has no effect upon it, and secondly, because after a laparotomy, any attempt to reduce the intussusception tends to increase the retrograde invagination and so make matters worse." Moutard Martin,⁴⁸ Knaggs,⁴⁹ and Ryan³⁰ report similar cases.

In the cases of Kleberg⁵⁰ and of Sainet⁵¹ the descending intussusciptens enveloped the retrograde mass (Fig 1, d).

IV Traumatic Intussusception Leichtenstein⁵² in 1873 reported a series of 326 cases of intussusception in whom there was available a thorough history, of these 26 or 8 per cent had a definite history pointing to trauma as the etiologic agent. He stated further that "The first symptom of the intestinal invagination usually followed the traumatic effect immediately." In the 26 cases contusions of the abdomen accounted for 14, and concussions or severe physical exertion was indicated in the remaining 12. Eliot,⁵³ Haun³³ and others^{54-57, incl} have contributed reports in which a sudden increase in intra-abdominal pressure has apparently caused an intussusception. Hipsley⁵⁹ reported 100 cases of intussusception and stated that "several of the cases began immediately after a fall out of a perambulator."

Instances of multiple areas of intussusception following trauma have also been described. Le Conte²⁸ in 1898 treated a nine-year-old boy who had been stabbed in the left side of the abdomen. Celiotomy revealed a direct jejunal intussusception about one inch long. About two feet distal to it two additional invaginations were found, one direct and the other retrograde, each was about $\frac{3}{4}$ inch long (Fig 1, b). No signs of inflammation, congestion, or change in the color of the intestine were present, and reduction was accomplished by very light traction. W. C. Peters³⁶ found three separate areas of intussusception in an eight-year-old boy who had suffered an abdominal injury in an auto accident. Badertscher²⁷ reported a similar case in a nine-year-old boy whose lower abdomen was run over by two wheels of a truck. This child had three typical areas of intussusception.

Case Report—G. E. N., technician 5th grade, 104th Infantry Division, vicinity of Duren, Germany, January 9, 1945, at 6:30 P.M. while manning a jeep-mounted 30-caliber machine gun, was struck in the left lumbar area by a fragment of an aerial bomb that detonated some 10 yards away. Presumably the bomb was a 200-250 Kg anti-personnel missile, and the effect of the combined blast and shell fragment was to knock G. E. N. from his weapon. He estimated that he was able within a matter of several seconds to rise and aid 2 mortally wounded comrades to places of safety some 50 feet distant. He subsequently collapsed and during the next 8 hours' evacuation received 2 units of plasma in both the collecting and in the clearing stations. On admission to the Shock Ward of the 53rd Field Hospital, 2nd Hospital Unit, Eschweiler, Germany, he was found by Captain J. O. Price to be in moderate shock and in the next 30 minutes was given 1000 cc of blood. Physical examination revealed a 1 cm in diameter per-

forating wound of the left upper lateral gluteal area with a 3 cm in diameter wound of exit at the left pubic tubercle. This latter area was filled with blood clot. Circulation of the left lower extremity was normal. There was no evidence of a "blast injury" to the eyes, ears, or lungs (physical examination and roentgen-ray). Roentgen-ray revealed a compound fracture of the left acetabulum and pubis. At 3:30 A.M. (9 hours post-injury) on January 10, under intratracheal gas-oxygen-ether anesthesia (administered by Capt. Alvin Leonard) a left lower rectus-splitting celiotomy was performed by Major L. L. Hall and myself. A severe laceration of the sigmoid colon, an incomplete transection

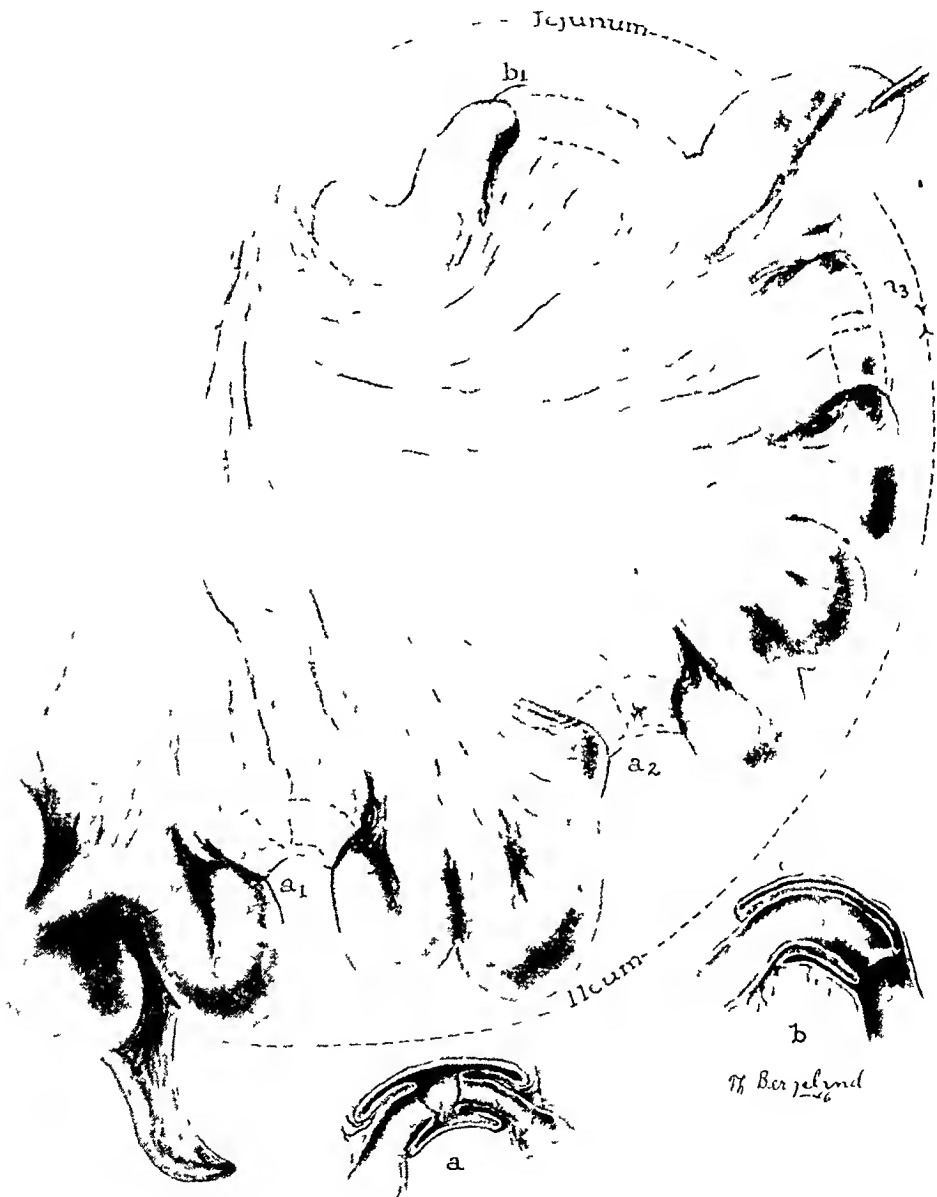


FIG 2—Multiple areas of direct and retrograde intussusception. A. Sagittal section of type of invaginations found in areas a_1 , a_2 , and a_3 . B. Classical intussusception sagittal section of invagination found in area b_1 .

of the external iliac vein, and a transection of the inferior epigastric artery were discovered, and these lesions were repaired. The gastro-intestinal tract was then further examined. Located in the mid jejunum was a 3.5 cm long area of intussusception (Fig 2). Lower in the jejunum and in the ileum were 3 areas of a Fig 1, type b, contiguous direct and retrograde intussusception. The invaginated areas each measured about 2 cm in length and were milked out with a moderate degree of difficulty. A transitory slight blanching of the intussusciens was noted. There was no peristaltic effort made to reform these areas nor was there any apparent abnormality in the small intestine. The appendix had been removed in 1937, and the patient stated that the only abnormality found at that time was that his appendix "was behind the colon."

Convalescence was uneventful, and the patient was evacuated on his 17th hospital day. His colostomy was subsequently repaired and when heard from on April 10, 1947 he was in good health, had had no recurrence of any gastro-intestinal disturbance, and was attending college. Never in his life had there been signs or symptoms suggestive of a disturbed autonomic nerve balance.

DISCUSSION

It is held that trauma was the etiologic agent in this instance of multiple area of direct and retrograde intussusception. Presumably in this case the nerve tension of battle caused a violent central (Bockus⁵⁸), and adrenergic stimulation of the sympathetic nerves of the gastro-intestinal tract with a resultant spasm of the sphincters and segmental spasm of bowel (McSwiney⁵⁹). The abdominal wall blast, though the positive wave was applied to the patient's side and to his back, gave rise to enough increased peritoneal cavity pressure to drive many spastic areas into adjacent areas of relative dilatation. The effect of the fall to the floor of the jeep would have the same effect. Of more than academic interest, too, would be the knowledge of what is the effect of some of the more highly seasoned of the K and C rations on the intestinal motility, this patient was injured only a few minutes after a meal of one of those stock front line rations.

One might well question why, if of traumatic origin, this should be the only case report to be found in the voluminous literature welling from this War, this was the sole instance of such a finding in our own review of 1,063 acute war wounds of the abdomen and chest^{60, 61, 62}. Thus, it must be admitted that more factors than trauma alone are involved, viz, the factors of a recently ingested meal, severe fright, and the still possible existence of some autonomic nerve imbalance in the soldier. Yet, it seems apparent that without trauma as the trigger mechanism these other factors never would have produced the remarkable lesions.

CONCLUSION

A review of the literature and a case report is presented of multiple areas of direct and retrograde intussusception of traumatic origin.

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CARCINOSARCOMA OF THE UTERUS^{*}

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CARCINOSARCOMA has been reported in many organs but the site of predilection is the uterus Robert Meyer¹ divides it into three groups (1) collision tumor, in which a carcinoma and a sarcoma arise at different sites and fuse by growth contiguity, (2) combination tumor, in which the two malignant elements are derived from one stem cell, as in the Wilms tumor, (3) composition tumor, in which parenchyma and stroma of a single tumor become neoplastic Jaffé² would limit the term carcinosarcoma or sarcocarcinoma to the last group and it is so used in this communication

The carcinosarcomatous nature of uterine tumors has been questioned by several observers Saphir and Vass³, in a review of 36 cases from the literature, stated that perhaps three or four may possibly be so designated but do not fully accept them Outerbridge⁴ believed that there was no such entity as "carcinosarcoma" Willis⁵ in 1924, stated that in human pathology, there was no acceptable example of a sarcomatous change in the stroma of a tumor Pitfalls in the diagnosis have been pointed out by many observers, the chief one being the marked polymorphism of carcinoma cells^{3, 6, 7} which, when anaplastic, can closely resemble sarcoma cells Saphir and Vass also stress other features which may cause difficulty—chronic inflammatory cells in the region of the tumor, a history or histologic evidence of irradiation therapy, and the fact that of the reported cases, none have had metastases showing the combined feature, the malignancy has been either pure carcinoma or pure sarcoma

The development of carcinosarcoma is explained by Jaffe as due to three possible mechanisms (1) the primary tumor is carcinomatous and the stroma develops sarcomatous features, (2) the sarcoma is first and is followed by carcinomatous changes, (3) both blastomatous elements develop simultaneously Ewing⁸ believed that at the point where a sarcoma reaches the endometrial surface, carcinoma could develop secondarily or that a common irritant could produce neoplastic changes in both elements It is well known that such tumors occur in animals both spontaneously and under experimental conditions Our interest in carcinosarcoma of the uterus was aroused by the following two cases which came under observation

* Since this article was written, the report of Stein (Monatschr f Geburt u Gynak 36, 417-438 1912) has become available He reported a case of a 46-year-old woman with adenoacanthosarcoma, associated with adenomyosis of the uterus and having extensive sarcomatous abdominal metastases

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CASE REPORTS

Case 1—The patient, a white woman 63 years old, was first admitted to Doctors Hospital on July 31, 1945, because of metrorrhagia of three months' duration. Menopause had occurred 10 months previously. Since the onset of the current illness, there had been periodic spotting and bleeding, without any weight loss. The only other features of note were chronic constipation, slight exertional dyspnea, palpitation, ankle edema and frequent headaches.

Examination revealed an elderly obese woman, not acutely ill, whose heart was slightly enlarged with a soft systolic apical murmur, a blood pressure of 190 systolic and 110 diastolic and a slight albuminuria. Otherwise there was nothing of note.

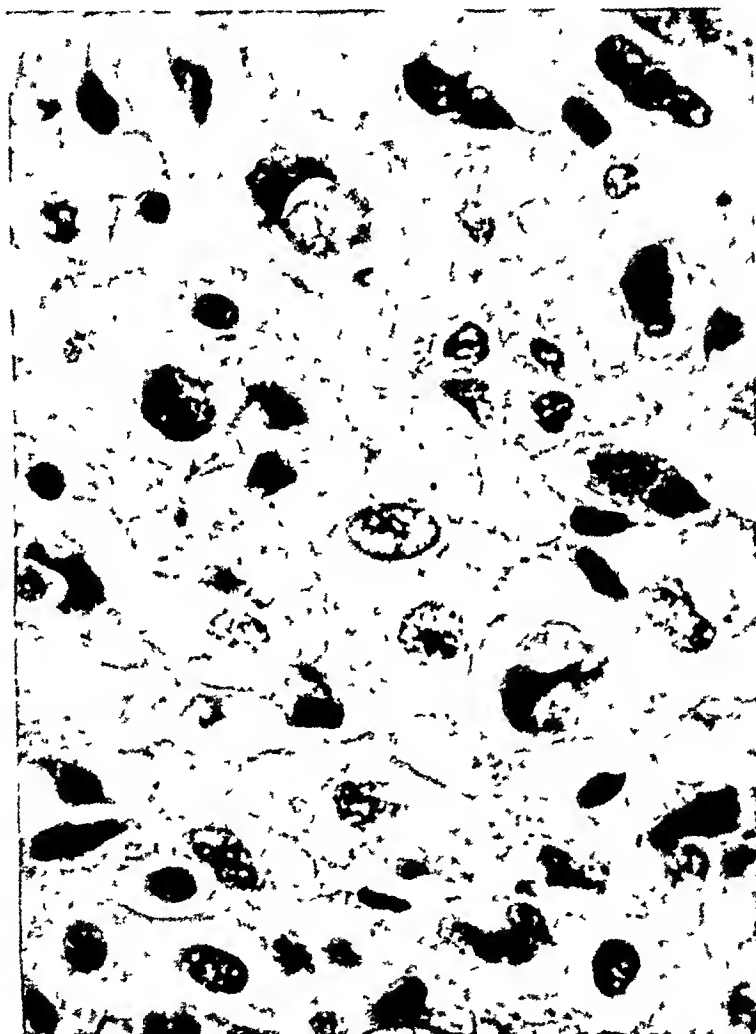


FIG 1—Case 1 Retroperitoneal sarcoma $\times 600$

Curettage gave considerable amounts of papillary cauliflower tissue, obviously malignant, so hysterectomy was performed. The histologic diagnosis of endometrial carcinoma was made by one of us (JRL). The uterus was enlarged and distorted by many intramural fibroids, the largest 3 cms. The endometrium showed only the changes seen after curettement. The fibroids showed only the usual changes, there was no evidence of malignancy. During the postoperative course, pyuria and albuminuria developed. She was discharged August 12.

* Thanks are due to Dr. John H. Garlock for the clinical data of this case.

About six weeks after leaving the hospital, signs of peritoneal irritation developed and a mass in the right lower quadrant which rapidly increased in size. There was no weight loss. She was readmitted to the hospital on December 12. A large hard nonpainful, nontender mass about the size of a fetal head was palpable in the lower abdomen, apparently semifixed and somewhat globular. There was a moderate anemia.

At operation, a large retroperitoneal mass filled the right lower quadrant, was bluish in color and consisted of gummy material with soft white masses of fish-flesh appearance. There was excessive bleeding. Death occurred January 1, 1947. Autopsy was not obtained.



FIG 2—Case 1. Curettings showing atypical malignant epithelial surface cells and atypical stromal cells with atypical triangular mitosis, indicated by arrow. $\times 600$

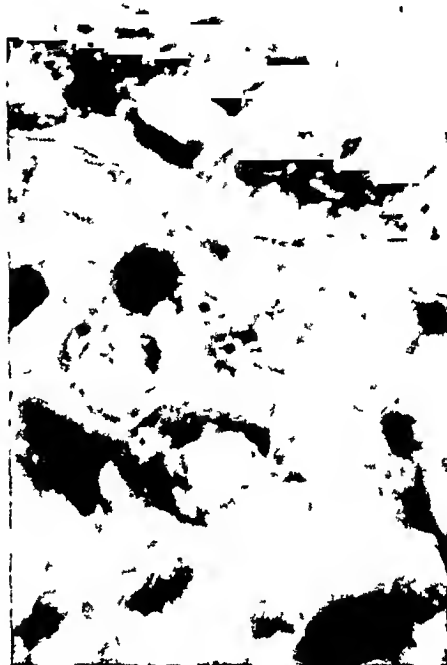


FIG 3—Case 1. Curettings showing the single layer of carcinomatous cells and the atypical hyperchromatic stromal cells. $\times 600$

Microscopy of the retroperitoneal mass showed typical sarcoma (Fig 1). Re-examination of the previous curettings revealed a feature which had been overlooked. In addition to the carcinomatous epithelium, the stroma consisted of atypical cells showing marked variability in size, hyperchromatism of nuclei and atypical mitoses (Figs 2 and 3).

Final Diagnosis—Carcinosarcoma of the endometrium with retroperitoneal metastatic sarcoma, multiple fibromyomas of uterus.

Case 2—The patient was a 54-year-old white woman of U. S. nativity admitted to Goldwater Memorial Hospital, service of Dr. Condict W. Cutler, Jr., on January 24, 1946, because of vaginal bleeding. The current illness began suddenly four days previously with lower abdominal cramps followed by vaginal bleeding increasing in severity until a few hours previous to entering the hospital.

Menses began at 9, occurred every 20 days and lasted for five days with a moderate flow. There had been two normal pregnancies. At 44, there were periods of vaginal bleeding lasting for weeks, interrupted by a few free days. An artificial menopause was induced with radium. During this year and the next, there were attacks of prolonged

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vomiting of undetermined origin. Until the age of 47, vaginal bleeding ceased, to reappear two to three times annually for the next three years. The bleeding episodes were painless, discharge had never been noted. Until the current illness, she had remained asymptomatic.

There was a past history of mild cardiac failure, a moderately high tension for many years and attacks apparently of gallbladder disease with right upper quadrant pain and marked idiosyncrasy to fatty foods. At 27, she had an appendectomy and right ovariectomy and at 31, pneumonia, empyema and a period of observation at Saranac. At 43, the gallbladder had been removed. During the last few months, there was vague costovertebral angle pain and some weight loss.

Physical examination showed a plethoric, intelligent, white woman. The right lower quadrant was tender, had slight spasm on deep palpation and a sense of fulness but without definite mass. Vaginal examination showed a normal cervix. Further gynecologic examination was not carried out for fear of precipitating further bleeding. The

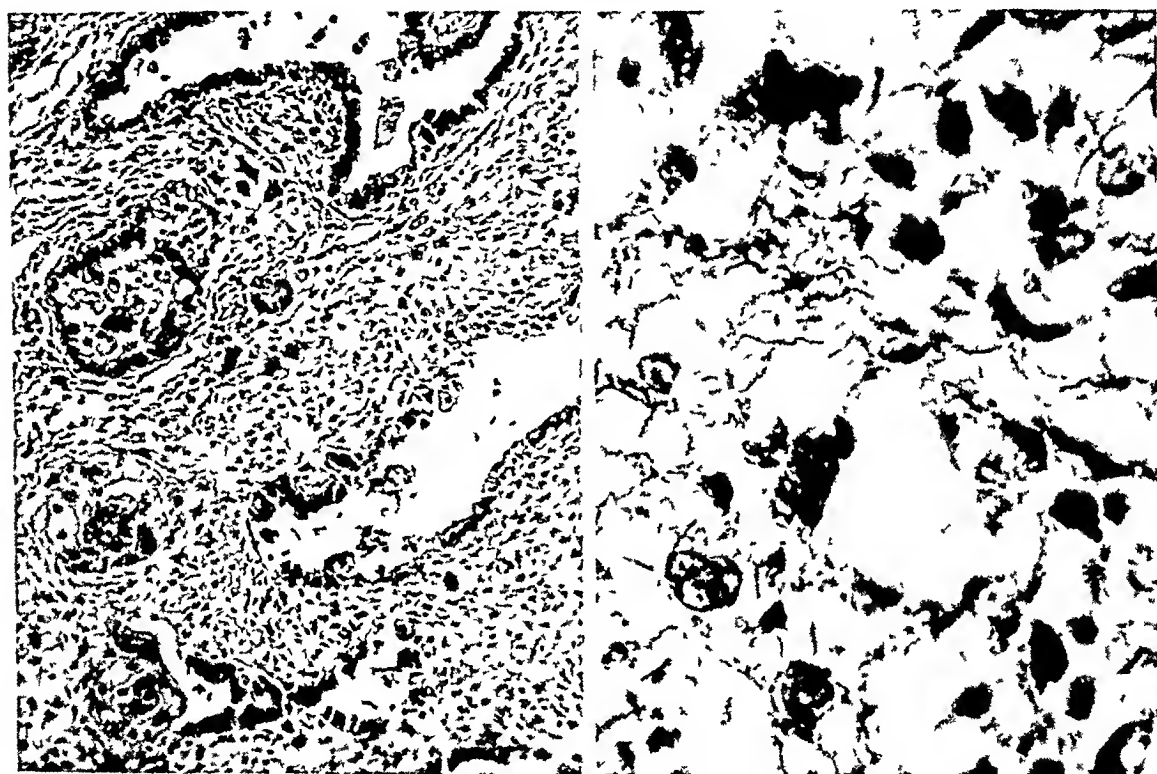


FIG 4—Case 2. Endometrial surface showing glands lined by atypical cells and deeper areas with malignant squamous metaplasia. One gland has both types of malignant cells. $\times 90$.

FIG 5—Case 2. Endometrial stroma with large hyperchromatic macronuclei. $\times 400$.
general examination showed a heart with an apical systolic murmur, an accentuated second aortic sound, no evident enlargement, blood pressure 200 systolic and 105 diastolic. Clotting time was 3 min, bleeding time 1 min. Other laboratory tests showed nothing of note.

Laparotomy was performed on January 25. A large semicystic boggy uterus about the size of a three months' pregnancy was found and removed supracervically. The stump was quite friable.

The postoperative course was uneventful and she was discharged on the 17th hospital day.

Pathology Report—The uterus, 9 x 6.5 x 9 cms is removed supracervically with the left tube. On opening it contains a degenerating semigelatinous gray-brown mass which is adherent in only a few areas and generally separates with ease, leaving a relatively irregular firm surface. The wall measures 1 cm in thickness.

Microscopy—The endometrial glands and surface are lined by neoplastic tall columnar cells. The glands penetrate deeply into the wall, where they preserve their architecture and have pronounced papillation. In the endometrium they tend to be somewhat scantier than usual and have transitions to malignant squamous cells (Fig 4). Striking changes are present in the endometrial stroma. There are many small hemorrhages, some of which enclose greatly dilated capillaries. The stromal cells (Fig 5) tend to be large, many of the nuclei are hyperchromatic, of increased size, have macronucleoli and bizarre mitoses. There are several large nests with giant nuclei. The stromal cells are in sharp contrast with the epithelial cells. Reticulum stains show fine fibers, in the large nests, they are extremely abundant. Cells similar to those of the surface endometrial stroma are not found within the myometrium.

Diagnosis—Carcinosarcoma of the endometrium

Gebhardt⁹ in 1899 appears to have reported the first case of carcinosarcoma of the uterus. Meyer, after a personal examination of the slides, accepted it as authentic. Frankel¹⁰ in 1901, reported the second case. The patient, 58 years old, for several months had profuse vaginal discharge which occasionally was bloody. The curettings were malignant and hysterectomy was performed. There were several myomas, the largest showing fibrillar sarcomatous cells enclosing papillary carcinomatous glands. The remainder of the endometrium had areas of hyperplasia, atrophy or granulation tissue. Ten months later the discharge recurred and a fungating tumor developed in the scar. She died of peritonitis a few weeks later. Autopsy revealed a necrotic carcinoma of the ovary adherent to the bowel which had perforated. The patient of Bernstein¹¹ was 52 years old. Uterine bleeding, more or less constant, reappeared at 48, 14 years postmenopausal. Curettage two years later revealed carcinoma but operation was refused. Panhysterectomy was performed two years afterwards, following an acute episode of intense lower left-sided pain and five weeks of continuous vaginal bleeding with foul discharge, weight loss and anorexia. During operation, the uterus tore loose from a very friable cervix and a metastatic mass was found in the omentum. The uterus was enlarged and filled with friable gray material infiltrating the wall. The endometrium after cleaning, appeared ulcerated. There was a diffuse invasion by carcinomatous glands and in some areas, closely associated with the carcinoma, was myosarcomatous tissue showing myofibrils and intercellular collagen, these areas were free of necrosis. The author interpreted the sarcomatous changes as reactive to long standing carcinoma. Klee¹² reported the case of a 58 year old woman who, six years previously, had an artificial menopause produced by x-ray therapy for hyperplastic polypoid endometrium proven by histological examination. The current illness was characterized by uterine bleeding and the curettings were diagnosed sarcoma. Panhysterectomy was performed. The endometrium showed both carcinomatous glands with columnar, cuboidal and squamous cells and neoplastic stroma having giant cells and intercellular fibrils. The patient was well 1½ years later. R Meyer's case¹³ had carcinomatous and sarcomatous changes of the endometrium. Horálek¹⁴ reported a case of a 56-year-old woman. Menses were regular to the age of 50, then menorrhagia developed lasting 14 days. During the last three months, bleeding was continuous and there were several severe hemorrhages. The

uterus was enlarged, moderately soft and had a cherry sized polyp protruding from the cervix which showed histologically carcinomatous endometrial glands buried in sarcomatous stroma. Hysterectomy was performed. The endometrium was diffusely involved by polypoid growths of similar character to that previously examined. The patient was well three years later. The patient of Daniel and Lazaresco¹⁵, 48 years old, one year after menopause, developed metrorrhagia followed by increasingly sanguinolent fetid discharge. The uterus was enlarged to the size of a six months' pregnancy. Total hysterectomy was performed. A peach sized polypoid mass arose by a broad base from the anterior wall, its surface fish-flesh in color. There were atypical papilliferous glands intermingled with atypical stroma. Various parts showed variable degrees of admixture. Harvey and Hamilton¹⁶ reported two cases. One was an adenomyoma with carcinomatous and sarcomatous changes. The second was a carcinoma surrounded by malignant stroma. They believed that the stromal neoplasm developed secondarily to the carcinoma. Dixon and Dockerty's¹⁷ patient was 34 years of age and two years postmenopausal. Four years previously she had received a half menopausal dose of radium following curettage, the diagnosis histologically of "endometritis" having been made. Vaginal bleeding and intermittent right lower abdominal and lumbar pain occurred a few weeks before she came under observation. A polypoid mass resembling placental tissue protruded through the os. Tissue removal by curettage was diagnosed sarcoma. The uterus, removed in toto with the adnexa, had a sessile polyp arising just above the internal os and showed papillary carcinomatous glands surrounded by neoplastic stroma. There were many benign fibroids. The patient of Barnes¹⁸ was 48 years old. The onset of illness was three years postmenopausal with watery leucorrhea for six months and increasing spotting for six more months. Curettings were sarcomatous. Panhysterectomy was performed. There was found a local endometrial mass showing both sarcoma and papilliferous adenocarcinoma. A separate myoma was present.

The clinical symptoms of carcinosarcoma of the uterus have no distinctive features different from any other malignancy. Most of the cases have occurred after the menopause, whether spontaneous or artificially induced. In some, the sarcomatous change appears to have developed subsequent to the carcinoma, as is suggested by the case of Bernstein. In all, the sarcoma has been of endometrial origin. It is of interest to speculate on the role of radiation therapy in the development of this type of tumor. In the cases of Klee, Dixon and Dockerty and our case 2, this type of therapy had been used. Our knowledge of the late effects of minor therapy in the human is scanty and it is possible that, in susceptible individuals, malignant changes may take place after a relatively long period.

SUMMARY AND CONCLUSIONS

The literature on carcinosarcoma of the uterus is reviewed. Eleven cases are accepted as authentic and two more are added. All 13 are of endometrial

origin All occurred after the menopause The clinical symptomatology presents the usual features of uterine malignancy Three cases had irradiation therapy previous to the development of the neoplasm and a possible causal relation is suggested The sarcomatous change apparently may precede, follow or be coincidental with the carcinoma

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CONGENITAL ABSENCE OF THE GALLBLADDER WITH CASE REPORT

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CONGENITAL ABSENCE of the gallbladder is a rare anomaly Gross¹ in a review of the literature in 1936 was able to find only 38 cases reported since 1905 Since 1936, 13 additional cases²⁻⁷ have been reported Dixon and Lichtman⁸ in 1945 added ten cases from both operative and necropsy records of the Mayo Clinic This anomaly is probably not as rare as these reports would indicate Undoubtedly many cases are encountered, which are simply not recorded A truer estimate of the incidence of congenital absence of the gallbladder will be reached only if all cases are reported This will also help in focusing attention on certain surgical aspects of this condition, as well as aid in the study of the patho-physiologic changes which take place in the post cholecystectomy state

Only the 60 cases reported since 1900, which are available to us, will be considered in this review, since many of the cases reported previous to that time are lacking in details and found unsatisfactory for analytical study Cases of congenital absence of the gallbladder, associated with atresia of the extrahepatic ducts will not be considered since they concern an entirely different problem A case encountered by us will be presented

The causes listed for this anomaly are many Two, however, stand out Both of these deal with the embryologic development of the liver and bile ducts The two theories are as follows (1) The hepatic diverticulum from the foregut forms the liver, gallbladder and extrahepatic bile ducts The gallbladder and cystic duct form an outpocketing from this diverticulum Failure of development of this outpocketing would cause an absence of gallbladder and cystic duct

(2) The gallbladder, hepatic, cystic and common ducts in their early embryologic development are hollow structures In the so-called solid phase, their lumina become obliterated Failure of the gallbladder and cystic duct portions to recanalize, would cause an absence of these structures

The condition is more common in women than in men, with 38 cases found in women and 23 in men One report did not mention sex This falls in line with other hepato-biliary diseases The average age of the patients was 46 years

In 26 of the 60 cases, the condition was found at necropsy In not one of these cases was the cause of death hepatic or cholecystic disease These patients apparently had no symptoms referable to this anomaly Symptoms suggestive of cholecystic disease were present in 37 cases Jaundice was present in 30 cases

In 17 cases cholecystographic studies were carried out and failed to reveal a gallbladder. The diagnosis of nonfunctioning gallbladder and cystic duct obstruction was frequently made. In no case, to our knowledge, was this anomaly diagnosed preoperatively.

The gallbladder fossa in the liver was present in seven cases and absent in 27. In the others it was not mentioned. The common duct was dilated in about 50 per cent of cases in which the size of the duct was mentioned. Gallstones were found in the common or hepatic ducts in 18 cases, not found in 19 cases and not mentioned in 25 cases.

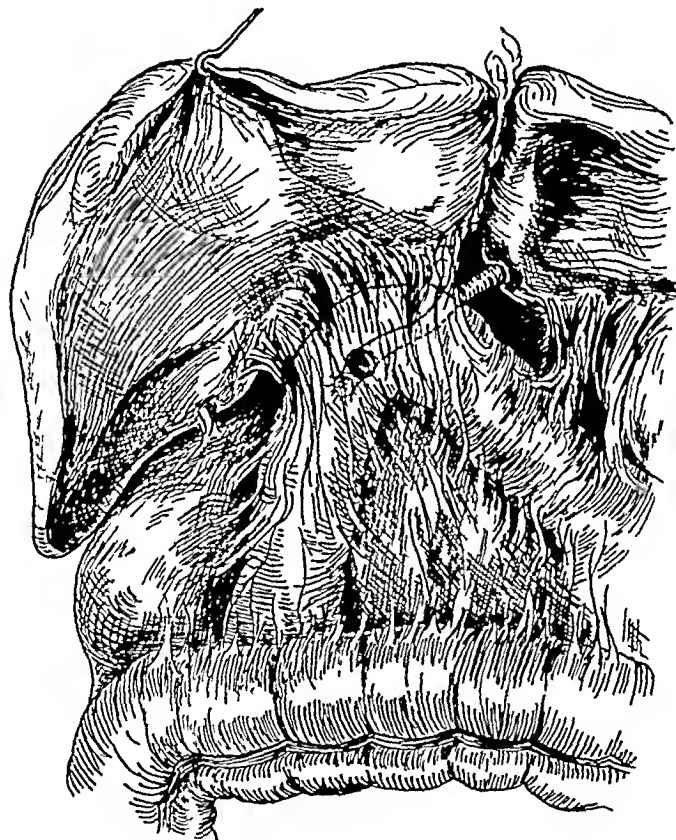


FIG 1—Artist's drawing of findings at operation. Wide fibrous band, holding duodenum up to hilar region of liver. Hepatic and common ducts readily visualized, with stone in the latter. No cystic duct or gallbladder outpouching to be seen.

The pancreas should be examined carefully, for Bower⁵ lays stress on the frequency of associated pancreatic disease. The pancreas was mentioned in 12 cases, pancreatitis existing in 11 of these.

Case Report—Hotel Dieu Hosp Case No G 9207 Mrs J C, 41 years old, female. Admitted to hospital on 4-3-46, with a history that for 4 months she had had severe pain in right upper quadrant, requiring morphine for relief. The pain radiated to the right scapula and right shoulder. Associated with the pain, she had fever and chills, nausea and vomiting. For 2 months she had been jaundiced, on and off, with the

jaundice varying in intensity She had lost 25 lbs in weight since the beginning of her illness

Her past history was essentially irrelevant

Physical examination showed a middle aged, moderately obese woman who was markedly jaundiced Pulse temperature and respiration were within normal limits



FIG 2 —Cholangiogram, taken on operating table All ducts are readily visualized but no vestige of gallbladder or cystic duct is seen

Sclerae were yellow Examination of the heart and lungs was normal The abdomen was soft, with tenderness in right upper quadrant There were no palpable masses The liver was moderately enlarged, with edge two fingers breadth below costal margin Spleen was not palpable

Gallbladder visualization studies showed no gallbladder shadow and no stones were seen on the plain film The radiologist made a diagnosis of gallbladder disease with

cystic duct obstruction Her laboratory studies showed RBC 4,770,000 Hgb 96.8 per cent WBC 8250 62 per cent polymorphonuclears Negative Kahn and Eagle Urine showed 2+ bile pigment and trace of albumin Prothrombin time was 30 sec (normal 15 sec) All other laboratory studies were normal A preoperative diagnosis of cholelithiasis, and cholecystitis with common duct stone was made The patient was placed on the usual preoperative preparation which included vitamin K and when the prothrombin time was 15 sec operation was carried out

Operation was performed on April 6th, 1946, with nupercaine (1-1500) spinal anesthesia The abdomen was opened through a right upper oblique incision The under-surface of the liver was exposed and the region explored No gall bladder was found The outer border of the duodenum was found attached by a short wide fibrous band to the hilar region of the liver (Fig 1) This was divided and the duodenum mobilized, exposing the common duct, which was about three times enlarged No gallbladder fossa was seen The common duct was explored upwards, to the point of junction with the two hepatic ducts These were followed to their point of exit in the liver No cystic duct, either fully developed or in the form of a stump was to be found No cystic artery was seen A large stone was palpated in the retroduodenal portion of the duct The pancreas was hard and suggestive of pancreatitis The common duct was incised, and the stone removed A catheter was passed through the ampulla of Vater to demonstrate patency The duct was irrigated with normal saline A T-tube was placed in the duct and the duct closed with interrupted silk sutures The appendix was removed One Penrose drain was placed at the foramen of Winslow and brought out with T-tube through the stab wound The wound was closed in layers with interrupted cotton sutures With the patient still on the operating table, a cholangiogram was performed and both hepatic ducts, common duct and smaller intrahepatic ducts were well visualized (Fig 2) No cystic duct or gallbladder was seen The dye was seen passing readily through the duodenum into the upper jejunum

Postoperative course was entirely uneventful The patient was discharged on her 18th hospital day, with the jaundice rapidly receding and the T-tube still in place The tube was removed on May 17th, 1946 and the stab wound rapidly healed The patient has been seen at frequent intervals and she has remained entirely relieved of all her symptoms, with no further reappearance of her jaundice

The possibility of an intrahepatic gallbladder was considered It is felt that this possibility was eliminated, as surely as one can with a live patient, by the search at operation, the immediate postoperative cholangiogram which failed to show any cystic duct or gallbladder, and finally by the complete relief of the patient's symptoms during the period of over a year since her operation

The possibility of an intrahepatic gallbladder must always be considered, when the gallbladder is not to be found in its usual position There are a few of these cases reported, many of them containing calculi One can with a fair degree of certainty, eliminate the possibility of this condition at the operating table by doing a cholangiogram, which should show all or part of the cystic duct and gallbladder, if they are present

SUMMARY

A review of some of the findings in congenital absence of the gallbladder is presented The necessity of considering the possibility of an intrahepatic gallbladder is brought out The value of a cholangiogram at the operating table in eliminating this possibility is presented

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HYDROCELE OF THE CANAL OF NUCK WITH LARGE CYSTIC RETROPERITONEAL EXTENSION

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TOWARD THE END of the eighteenth century Scarpa¹, in his book "Tumors of the Spermatic Cord," described a cystic tumor in the female inguinal canal which he referred to as "hydrocele of the canal of Nuck." Three prior instances had been reported by Aetius² 543 A.D., Plater³ 1536 A.D., and Bertrondi⁴ 1723 A.D. Moreover Desault 1737-1762, in the *Journal d'Chirurgie* had described a case in detail in which the diagnosis was made certain by operation and excision of the sac. In 1832 an Italian surgeon, George Regnoli⁵, Professor of Surgery at University of Pisa, prepared an exhaustive monograph on the subject, classified the various types and described an interesting case. Among others Chiari⁶ recorded three cases in 1879, Wile⁷ two in 1881, Coley⁸ 14 in 1892, and Halstead and Clark⁹ one in 1905. Halstead also referred to a case described by Thierhaber. In all Counsellor and Black¹⁰ estimated that approximately 100 instances of hydrocele muliebilis were reported from 1892 to 1939 and a total of not more than 350 cases have been reported until the present time.

Regnoli's description of hydrocele in the female still stands today with little alteration. He mentioned five types: (1) a diffuse hydrocele in cellular tissue enveloping the round ligament with transformation of the cellular tissue into a serous membrane, (2) an accumulation of fluid in a prolongation of peritoneum into the inguinal canal, the communication with the abdominal cavity remaining, (3) differs from the second only in the fact that the pouch of peritoneum no longer communicates with the abdominal cavity, (4) an encysted hydrocele in the connective tissue about the round ligament (similar to the first), (5) an accumulation of fluid in the remains of an old hernial sac.

When confined to the inguinal canal, hydrocele in the female first makes its appearance as a soft slightly tender often reducible mass in the inguinal region which is frequently mistaken for hernia. It may vary from the size of a hazel nut to that of a child's head. Seven of Counsellor and Black's cases were accompanied by hernia. Many were multilocular. Of 63 of his patients in whom the side of the lesion was known, Coley stated, that the right side was involved in 36, the left in 25 and both sides in two. In many, but not all reported instances, the inguinal canal cyst communicated with the general peritoneal cavity.

Throughout the literature seven instances of hydrocele of the canal of Nuck with an intra-abdominal cystic extension have been discovered. In five

of the seven there were acute abdominal symptoms. One was diagnosed strangulated hernia and three intestinal obstruction.

In 1905 Halstead and Clark reported a case in a 42 year old colored woman who was hospitalized because of a tender swelling in the right inguinal region. An enlargement had been present in that area for 18 years but acute pain and tenderness for only eight days. She had vomited twice. On admission her temperature was 99°, white blood count 13,000. A preoperative diagnosis of strangulated hernia was made. At operation a cystic tumor containing an ounce and a half of fluid was found in the inguinal canal. This opened into a larger intra-abdominal cyst, which communicated with the general peritoneal cavity through a small opening.

Halstead and Clark also referred to a case of Thierhaber. A woman 42 years of age gradually developed a tumor in the inguinal region. This swelling suddenly increased in size and became painful to touch. At operation a mass the size of a goose egg was found which projected below the external ring into the labium majora. With a diagnosis of partially obstructed hernia, operation was performed and revealed a bilocular hydrocele, one part within the abdominal cavity. The two chambers communicated but did not open into the free peritoneal cavity.

Three similar cases were reported by Chiari. In these there was inflammation of the wall of the sac which gave rise to symptoms of intestinal obstruction—vomiting, abdominal distention and obstipation. Operation revealed the nature of the condition.

Counselloi and Black reported 17 cases of hydrocele of the canal of Nuck. Among these one was a lemon sized, reducible, hour-glass type of tumor, an intra-abdominal part of which consisted of a large cyst in the iliac fossa. Another had a large cystic extension of the hour-glass type, chiefly intra-abdominal. There was no note of either of these hydroceles producing acute symptoms.

Because of the apparent rarity of this hour-glass type of hydrocele in the female, presentation of this additional case was felt to be justified.

CASE HISTORY

A 20-year-old colored girl, wife of an army corporal, was first seen in the hospital outpatient department on January 4, 1946, because of severe dysmenorrhea which she had had since puberty, manifested by abdominal cramps with each menstrual period for four years, and because of irregular vaginal bleeding of three years duration. A relatively normal menstrual period had occurred on November 5th, 1945, the last period having been on December 15, 1945. For about two years she had noticed a soft, non-tender swelling in the right inguinal region which caused no symptoms. Her past history had been non-contributory.

Physical examination revealed a fairly well developed girl in no apparent discomfort. Heart, lungs, pharynx, bones and joints were normal. There was a soft, slightly tender, reducible mass half the size of a walnut in the right inguinal region. The left inguinal region was normal. On pelvic examination cervix and perineum were normal. The uterus was moderately enlarged, firm, retroverted and tender. No masses were felt in the adnexia but there was tenderness in both vaults.

The urine was straw colored, hazy, contained no albumin or sugar but did reveal a few epithelial cells and 1-3 white cells per H P F Hematoerit 39 Kahn negative

With a diagnosis of right inguinal hernia and mild pelvic inflammatory disease she was admitted to the hospital on January 12th, 1946 Hospital history, physical examination and laboratory studies confirmed those recorded by the outpatient department, and operation for right inguinal hernia was scheduled for January 18, 1946

Operation—Under satisfactory procaine and pontocaine spinal anesthesia a right inguinal incision was made from a point one inch medial to the anterior superior spine downward to the pubic tubercle This incision was carried down to the aponeurosis of

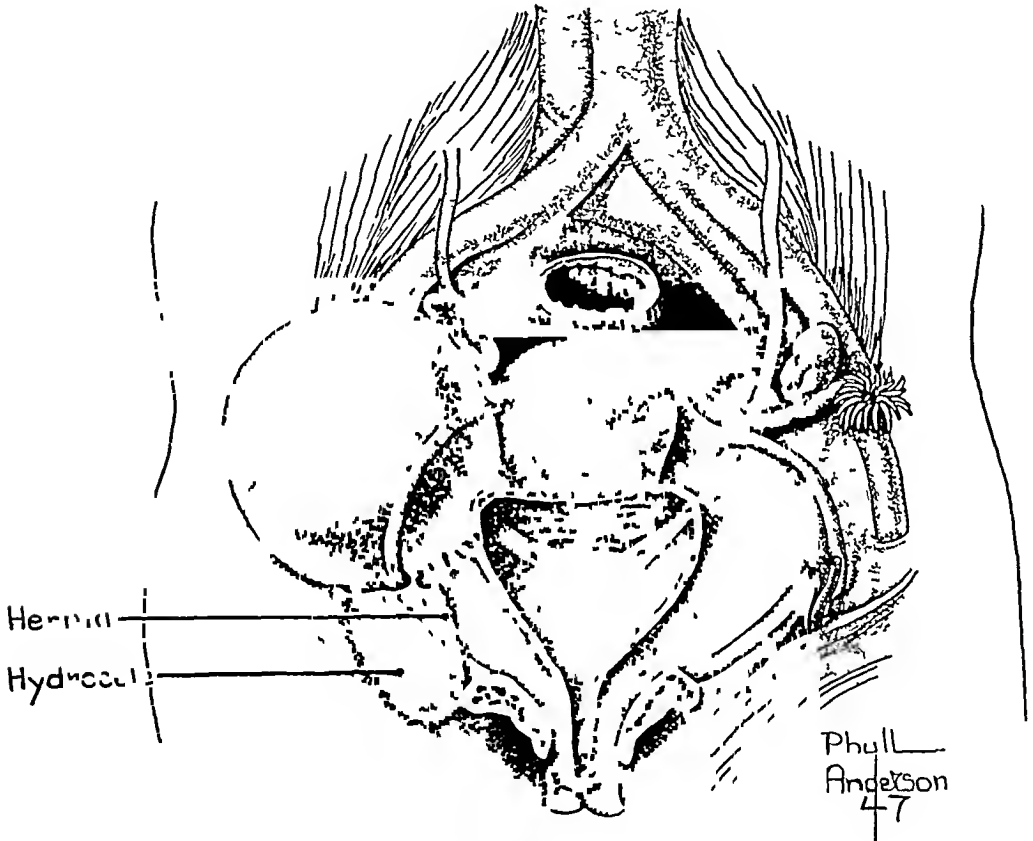


FIG 1—Hydrocele of the canal of nuck with retroperitoneal cystic extension and accompanying hernia

the external oblique muscle which was split in the direction of its fibers The round ligament was gently dissected free from the surrounding tissues Along the lower part of the ligament there were a number of loculated pockets containing clear yellow cystic fluid More laterally these seemed to unite to form a cystic cavity, sausage shaped, containing about 10 cc of clear fluid At the internal ring this cystic space was found to be continuous with a large intra-abdominal cyst slightly larger than an orange Connecting the two cystic spaces was a somewhat narrower neck By slipping a finger through this neck the distant walls of the intra-abdominal cyst could be felt On exploring further along the round ligament a true indirect inguinal hernia which communicated with the general peritoneal cavity was discovered The round ligament lay between the cyst and hernia

Because of the possibility that the cyst might be a diverticulum of the bladder, the bladder was catheterized on the operating table. It contained the usual amount of urine and did not communicate with the cyst. To explore the lesion more thoroughly the incision was then extended across the midline, the fascia dissected upwards, the rectus muscles separated vertically and the peritoneal cavity opened. It was then discovered that the cyst was entirely retroperitoneal accompanying the round ligament, its fundus lying between the layers of the broad ligament. Gradually from the inguinal and intra-peritoneal approaches the cyst was dissected free and wall delivered into the inguinal incision lateral to the hernia. The hernial sac was dissected out and tied off, the lower fanned-out portion of the round ligament excised and a Bassini type of repair of the inguinal canal performed.

The postoperative convalescence was entirely without incident.

Examination on July 13, 1946 revealed an enlarged retroverted uterus, slight tenderness of both adnexa and a well healed inguinal scar. Except for some continued irregularity of her menstrual periods she was symptom free.

In the case noted above, as in the two reported by Counsellor and Black the cyst did not cause symptoms, merely the presence of a mass in the inguinal region. The patients of Halstead and Clark, Thierhaber and Chiari however were treated because of acute episodes suggesting intestinal obstruction or strangulated hernia. In at least one of Chiari's cases there was evidence of acute inflammation of the wall of the cyst. On this account it seems reasonable to suppose that the acute symptoms described by these authors were due to inflammation of the adjacent peritoneum.

SUMMARY

A review of the literature of hydrocele of the canal of Nuck is presented. Emphasis is placed on seven previously reported cases of an hour-glass type in which part of the hydrocele was intra-abdominal. Another case of this type is described together with a suggested method of treatment.

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LIPOMA OF THE DUODENUM CAUSING MELENA

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BENIGN TUMORS of the duodenum are rare. Silent hemorrhage is often the only symptom of tumors of the small intestine. This paper is the report of an interesting case of an ulcerated lipoma of the duodenum, the only symptom being intermittent melena.

REPORT OF CASE

History and Physical Examination—C K, a 70-year-old white male, was referred to the George F Geisinger Memorial Hospital for gastro-intestinal studies because of a history of intermittent tarry stools for two years. The patient had enjoyed excellent health until early October 1944, when he had a sudden attack of weakness and dizziness. Following this he observed that his stools were tarry black in color for one week. There was no abdominal pain, nausea, or vomiting associated with the attack. No history of intolerance for fatty foods could be elicited. Similar, milder episodes had occurred subsequently at irregular intervals during the past two years. These were never associated with any abdominal symptoms. Between attacks the patient had no complaints. There was no weight loss. The last attack was one month before admission.

Physical examination revealed a well developed, rather obese white male in no distress. Weight was 195 pounds. Temperature, pulse, respiration were normal. B.P. 140/78. There were no masses or tenderness in an obese abdomen. The remaining portion of the examination was essentially negative.

Laboratory Examination—Examination of the urine was negative. Flocculation reaction for syphilis was negative. Blood studies revealed a mild hypochromic anemia with erythrocytes 3,950,000, leukocytes 2,450, hemoglobin 62 per cent, and color index 0.8. Tests for occult blood in the stools were negative.

Roentgenologic Examination—Roentgenologic examination of the upper gastro-intestinal tract revealed no evidence of organic disease of the esophagus or stomach. There was no gastric residue from the motor meal ingested six hours previously. The duodenal bulb was normal in size and contour. In the third portion of the duodenum there was an elongated mass 5.5 by 3 centimeters in size. No ulceration of the surface of this mass could be detected. There was no obstruction proximal to the mass which almost filled the lumen. Because of the position of the lesion and the habitus of the patient no contributory pressure films could be obtained. Films taken subsequent to fluoroscopy showed an apparently normal small intestine distal to the ligament of Treitz. The roentgenologic impression was "benign tumor of the duodenum possibly a leiomyoma."

Surgical Findings—A laparotomy was performed on June 26, 1946, by Dr. Harold L. Foss. Following exposure of the second and third portions of the duodenum, the tumor was readily palpated within the lumen. On opening the duodenum a soft pedunculated polypoid mass approximately 5 cm. long was found. The base of the pedicle was ligated and the tumor removed. Postoperative course was uneventful. On a follow-up visit several months subsequent to operation the patient stated there has been no recurrence of bleeding.

Pathologic Findings—Pathologic examination of the specimen showed a soft ovoid mass measuring 5 by 3.5 by 2 cm. in size. The surface was smooth and glistening and had the appearance of normal mucosa. At the distal pole there was a small bluish sear with tiny petechial hemorrhages about it. The cut pedicle measured 1.0 cm. Through the cut surface of the pedicle a soft yellow inner substance could be seen. Section revealed a normal reflection of mucosa over the tumor. The central mass was composed of three lobules of soft yellow adipose-appearing tissue.

Microscopic section confirmed the gross impression of adipose tissue. The mucosa was normal. Diagnosis was lipoma.



FIG 1—Roentgenogram showing tumor of duodenum

COMMENT

The incidence of benign tumors of the small intestine is given by Raiford¹ in his extensive survey as approximately 4 per cent of all gastro-intestinal tumors. Lipomas form only a small percentage of these. Generally these neoplasms are single but infrequently are multiple. The size varies from that of a pea to more than a man's fist. The common form is polypoid although a fair number of the sessile variety are reported.

There have been less than 20 lipomas of the duodenum reported to date. Most of these were incidental findings at autopsy. Degner's case as reported in Comfort's² comprehensive survey of submucous lipomas is the only proven case with symptoms we can discover.

Although benign tumors are rare, when they occur they often produce serious symptoms. In cases of adult intussusception of the small bowel, lipomas have been traced as the etiologic factor in 44 per cent—Schottenfeld³

Good and MacCarty⁴ list three primary clinical manifestations of benign tumors of the intestine. They are (1) loss of blood as by hematemesis or melena, (2) presence of a mass, (3) evidence of obstruction.

Intussusception in the duodenum is very unusual as it is fixed for the most part. Also, as the duodenum is deeply situated in the abdomen, palpation of a soft mass would be difficult or impossible. Hemorrhage follows ulceration of the stretched atrophic mucosa. There have been ten cases of spontaneous passage of lipoid tumors with bloody stools, presumably subsequent to avulsion of these polypoid growths.

It is obvious that if the diagnosis of benign small intestinal tumor is to be made prior to operation or necropsy, it must be made by the roentgenologist. Most tumors of the upper gastro-intestinal tract can be discovered

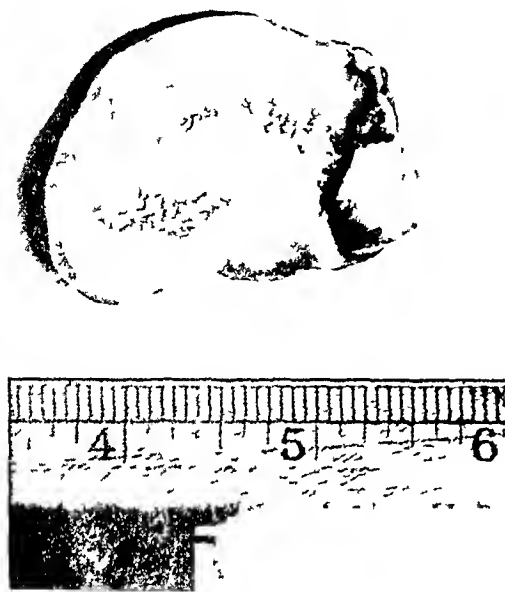


FIG 2—Photograph of gross specimen in the course of an ordinary roentgenoscopic study of the esophagus, stomach and duodenum. Tumors distal to the ligament of Treitz require special small intestinal studies such as are described by Golden⁵ or Schatzki.⁶

It is not always possible to make a roentgenologic differentiation between benign and malignant tumors. There is a high incidence of serious complications in all small intestinal tumors. For these reasons we believe that when the diagnosis of small intestinal tumor is made, the patient should be operated upon even in the absence of symptoms.

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A NEW METHOD OF RESTORING CONTINUITY OF THE ALIMENTARY CANAL IN CASES OF CONGENITAL ATRESIA OF THE ESOPHAGUS WITH TRACHEO-ESOPHAGEAL FISTULA NOT TREATED BY IMMEDIATE PRIMARY ANASTOMOSIS

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DECISION CONCERNING the treatment of congenital atresia of the esophagus with tracheo-esophageal fistula in any given case requires that the surgeon establish a general policy of management of this anomaly. At first this condition was regarded as hopeless. It was finally shown by Ladd¹ and others that the lives of some of these unfortunate infants could be saved by means of a multiple stage procedure consisting of closure of the fistula, the establishment of a cervical esophagostomy, and the creation of a gastrostomy for feeding purposes. In a few of these patients it has been possible with much effort to construct an external esophagus using tubed flaps of skin, segments of jejunum, and so forth. This procedure has admittedly been attended by many difficulties and disappointments and few real successes. More recently it has been shown conclusively by Haight,² Ladd and Swenson,³ and others that in many cases it is possible to close the fistula and to perform a primary anastomosis so as to create an intact esophagus. Perfections in technic resulting from increased experience have made it possible to perform this operation with a relatively high percentage of successful results in suitable cases. It is obvious, therefore, that if enough length of esophagus is available, closure of the fistula followed by the performance of a primary anastomosis is the operation of choice.

There remains, however, the problem of how to handle the case where it is impossible to carry out this ideal procedure. Attempts to construct an external esophagus in these cases have been so discouraging that some surgeons have expressed the opinion that it might be better to allow such unfortunate infants to die rather than to preserve them only for a life of suffering or semi-invalidism. No doubt the majority of surgeons would feel obliged to prolong the infant's life if possible by closing the fistula and performing a cervical esophagostomy and a gastrostomy. The parents of the child, on the other hand, sometimes adopt the other point of view—that it is better to allow the child to die hardly having lived, than to allow him to live with the handicap which is inevitable for him. This opinion must be regarded with sympathy.

It is apparent, therefore, that if a method of restoring the continuity of the alimentary canal without having recourse to the multiple stage external esophagoplasty usually advocated could be developed, it would make it easier for surgeons and parents alike to decide in favor of an attempt to preserve the life of the child in cases where a primary anastomosis cannot be made. A method to accomplish this end by performing an intracervical

esophagogastric anastomosis after pulling the stomach up through the chest is herein set forth

NATURE OF THE PROBLEM

The principal obstacles to be overcome are three in number

(1) *The long distance between the short proximal segment of esophagus and the fundus of the stomach* That the stomach can be mobilized sufficiently to place the fundus in the apex of the left pleural cavity has already been demonstrated¹ In the cases of congenital atresia which have been treated by cervical esophagostomy and gastrostomy, the anastomosis must be made several centimeters above the level of the clavicle because of the invariably short proximal stump of the esophagus which must be used If the mobilization of the stomach is complete, however, sufficient length can be obtained to bring the fundus as high in the neck as required This means, in addition to the usual freeing of the fundus and division of the left gastric and left gastro-epiploic vessels, the complete division of the gastrohepatic and gastrocolic ligaments as far as the level of the pylorus This dissection must be done with great care to avoid injury to the right gastric and right gastro-epiploic vessels and their anastomotic arches along the lesser and greater curvatures of the stomach

(2) *The presence of a gastrostomy opening* The performance of a gastrostomy is, of course, necessary in the type of congenital atresia which does not lend itself to a primary anastomosis But the presence of such a fistula does not present a very serious handicap because it can be closed readily after the stomach has been freed from its attachment to the anterior wall of the abdomen It is important, however, to close the opening in the gastric wall in such a way that no shortening of the stomach will result This is accomplished by placing the sutures across the stomach so that when they are tied, the opening is infolded in the direction of its long axis This produces slight narrowing of the lumen which is of no consequence and lengthwise shortening is avoided

(3) *The passage of the fundus of the stomach from the thoracic cavity into the neck* This presents a somewhat difficult problem which can best be solved by performing what may seem at first to be a rather radical maneuver It is not possible to develop by dissection a large enough passage-way from the superior mediastinum into the base of the neck to make room for the relatively large fundus of the stomach Furthermore, if the fundus is brought out through a short anterior intercostal incision and then up into the neck through a subcutaneous tunnel, the pressure of the overlying skin and fascia would cause too much compression of the stomach and anastomosis against the underlying structures Ample room for the fundus can be obtained, however by resecting the inner one-half of the clavicle and a comparable segment of the first rib so that the fundus can be passed into the neck without pressure or constriction to meet the high-lying proximal esophageal segment

DESCRIPTION OF THE OPERATION

The operation is performed in one stage as follows

(1) *First Step of the Procedure—Mobilization of the Stomach and Resection of the Distal Segment of Esophagus* The patient is placed on his right side with the left arm drawn forward out of the way. A long intercostal incision extending the entire length of the eighth interspace is made. A small size rib spreader is inserted. The diaphragm is incised from a point close to its costal insertion through the margin of the esophageal hiatus. The rudimentary distal segment of the esophagus is freed through an incision in the mediastinal pleura and removed by severing it just above the cardia. The remaining stump is inverted with a purse-string suture of silk reinforced by several Lembert sutures of the same material. The anterior wall of the stomach is then freed from its attachment to the abdominal wall and the gastrostomy opening is closed with two layers of fine silk sutures. The attachments of the fundus of the stomach are divided, including the gastrohepatic ligament with its enclosed vasa brevia which must be ligated. The left gastro-epiploic vessels are tied and cut and the entire gastrocolic ligament is incised all the way to the level of the pylorus, taking care to avoid injury to the arcade of vessels along the greater curvature of the stomach which is supplied by the right gastro-epiploic vessels. The left gastric artery and vein are tied and cut. The gastrohepatic ligament is then incised as far as the level of the pylorus. Here likewise the integrity of the vascular arches along the lesser curvature, which are supplied by the right gastric vessels, must be preserved. It is important to mention in this connection that the left gastric artery should be tied and cut close to its origin from the celiac axis so as to preserve the peripheral branches which form the greater portion of the arcade along the lesser curvature. The stomach is now sufficiently well mobilized to allow the fundus to be pulled up through the thorax to the base of the neck or above.

A strand of silk is then passed with a fine needle through the wall of the fundus of the stomach, which has been pulled through the diaphragm and up behind the hilum of the lung. A trochar-pointed needle (Keith) is substituted for the fine needle on the end of the silk strand. This needle is thrust from within through the first left intercostal space anteriorly and by means of traction on the attached thread of silk, the fundus of the stomach is held up against the anterior thoracic wall during the closure of the thoracotomy incision until it is needed for the performance of the anastomosis in the neck (Fig 1, No 4).

To complete the first stage of the operation the lung is expanded by the anesthetist and the thoracotomy incision is closed, using pericostal sutures of fine chromic catgut to approximate the ribs and interrupted sutures of fine silk in the remaining layers.

(2) *Second Step of the Procedure—Performance of the Intracervical Esophagogastric Anastomosis* After the closure of the thoracotomy incision

has been completed, the patient is turned on his back and a vertical incision is made from the esophagostomy stoma above to the level of the second rib below. The pectoralis major muscle is incised close to its attachment to the sternum and reflected laterally, at the same time separating its insertion to the medial portion of the clavicle. The sternal and medial clavicular insertions of the sternocleidomastoid muscle are severed and re-

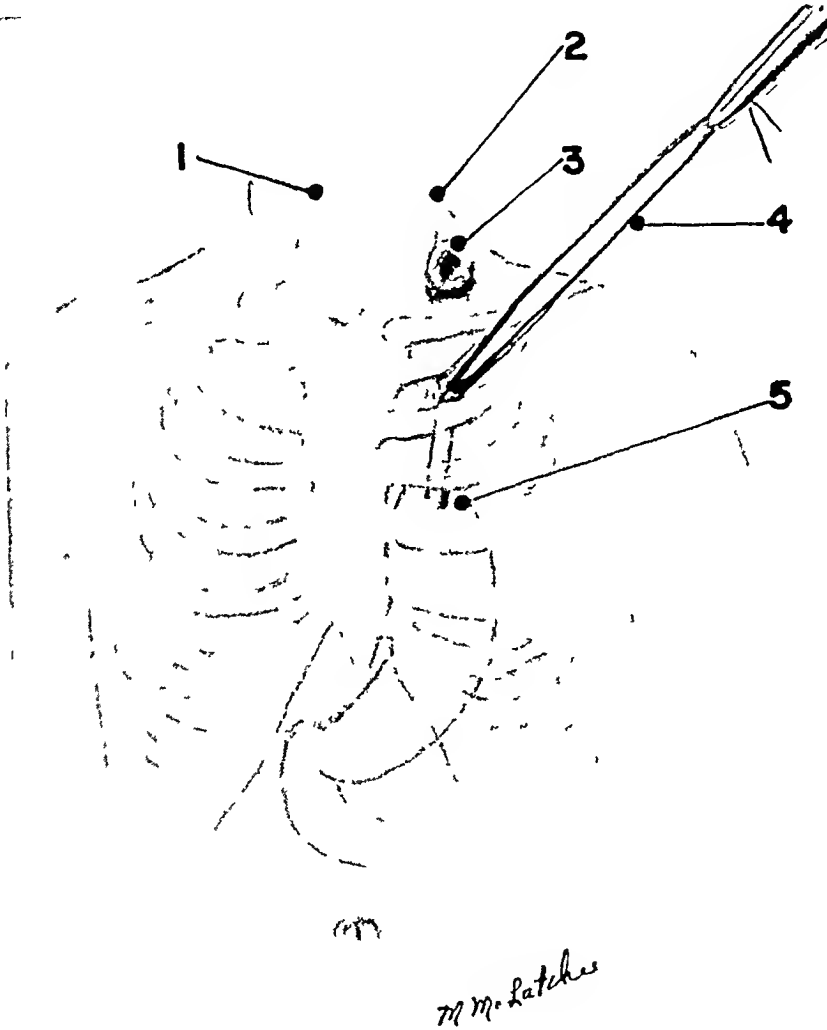


FIG 1—Diagram illustrating the method of maintaining the position of the fundus of the stomach in the apex of the chest during closure of the thoracotomy incision (1) Thyroid gland (2) Sternocleidomastoid muscle (3) Cervical esophagostomy stoma which is to be used for the anastomosis (4) Silk thread which is brought out through the first intercostal space and used to hold the fundus of the stomach in the apex of the chest until the thoracotomy incision has been closed. After the cervical incision has been made and the left pleural cavity opened from above the stomach is drawn up into the neck as shown in Figure 2. *Note* No attempt is made in this drawing to illustrate the relations of the stomach to the heart and left lung.

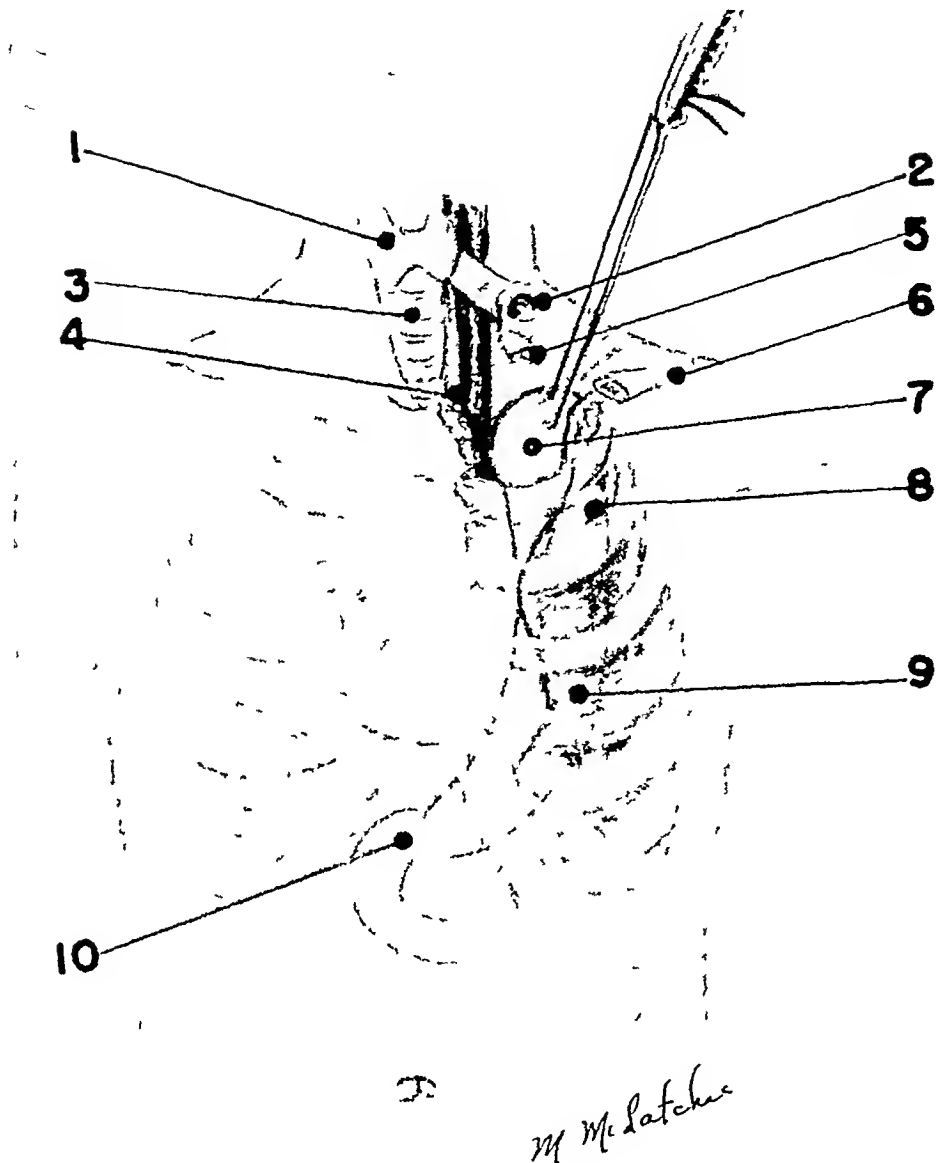


FIG 2—Diagram illustrating the method of bringing the stomach up through the left thoracic cavity and into the base of the neck. For the sake of clearness, the left sternocleidomastoid and pectoral muscles have been omitted from the drawing instead of being shown retracted laterally as is the case in the operation. The stomach lies behind the heart and the hilum of the left lung. The fundus of the stomach is shown being drawn up out of the pleural cavity into the neck. As this is done it passes medially to the apex of the lung and in front of the subclavian artery and vein. The short proximal length of esophagus passes anterior to the carotid sheath. The anastomosis therefore lies in front of the carotid vessels. (1) Thyroid gland (2) Stoma and short proximal end of the esophagus (3) Trachea (4) Carotid vessels (5) Cut end of the first rib after resection of the anterior segment (6) Lateral one-half of the clavicle showing cut end after resecting the medial one-half (7) Fundus of the stomach with temporary silk thread still in place (8) Left lung lying anterior and lateral to the stomach (9) Apex of the heart (10) Duodenum pulled somewhat to the left

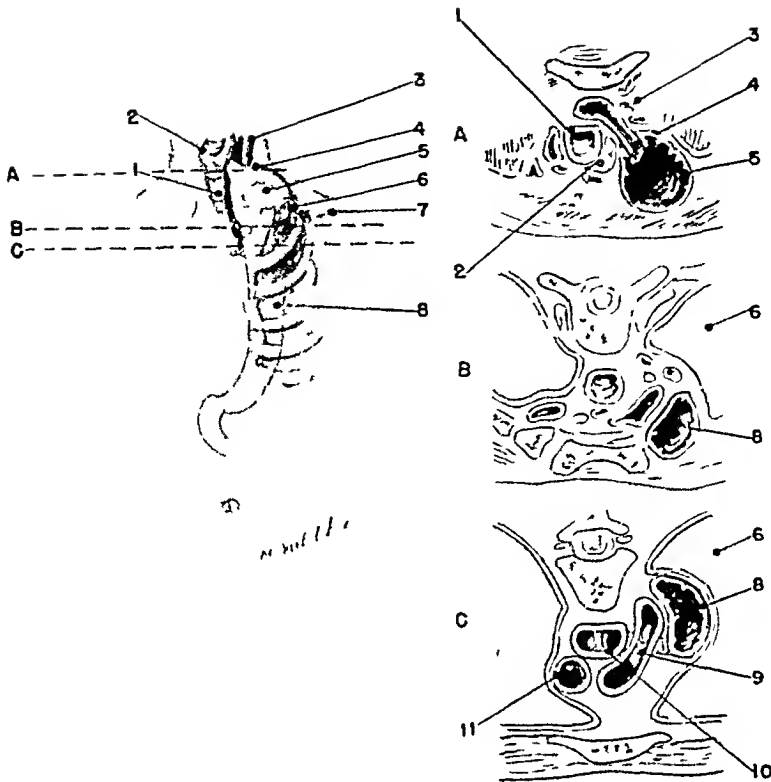


FIG 3—Diagram showing the relations of the stomach after the completion of the anastomosis (1) Trachea (2) Thyroid gland (3) Carotid vessels (4) Esophagogastric anastomosis (5) Fundus of the stomach (6) Apex of the left lung (7) Lateral half of the clavicle (8) Level of the body of the stomach where it lies behind the hilum of the lung

Cross Section A Level of the esophagogastric anastomosis in the neck (1) Trachea (2) Thyroid gland (left lobe) (3) Carotid and jugular vessels (4) Esophagogastric anastomosis (5) Fundus of the stomach

Cross Section B Level of the dome of the pleural cavity (6) Left lung (8) Stomach

Cross Section C Level of aortic arch (6) Left lung (8) Stomach lying behind the hilum of the left lung (9) Aortic arch (10) Trachea looking down at the bifurcation (11) Superior vena cava

tracted laterally. The incision is then carried around the esophageal stoma and enough of the end of the esophagus is freed to make it possible to perform an anastomosis. This mobilization of the esophageal segment must not be too extensive for fear of jeopardizing the blood supply to the end which must be preserved for the anastomosis.

The medial half of the clavicle and a corresponding segment of the left first rib and costal cartilage are resected extraperiosteally. This produces a large opening from the base of the neck behind the lower end of the sternomastoid muscle into the apex of the left pleural cavity through which the



FIG 4—Case W C Pre-operative roentgenogram showing barium taken orally after spitting onto the neck through the esophageal stoma, and barium put into the stomach through the gastrostomy catheter with a faint trickle of barium extending several centimeters into the distal blind segment of the esophagus (Arrow)

fundus of the stomach can be drawn easily and without danger of compression. The temporary fixation of the fundus of the stomach is eliminated by cutting the silk suture which was used to attach it to the tissues of the first intercostal space. The fundus is pulled up behind the apex of the lung into the lower portion of the neck (Fig 2). A short incision is made in the posterior wall of the fundus close to its apex and an anastomosis consisting of three layers of interrupted fine silk sutures is made. Careful approximation of mucosa to mucosa and muscle-edge to muscle-edge constitute the inner and middle layers. The outer layer is of interrupted mattress sutures. Several interrupted sutures are used to fix the fundus to the tissues surrounding the region of the anastomosis. The method of pulling up the fundus of the stomach and the location of the esophagogastric anastomosis

at a high level in the neck is illustrated in Figures 2 and 3. The wound is closed by re-suturing the lower end of the sternocleidomastoid muscle and the cut edge of the pectoral muscle to the sternum and placing a layer of fine silk sutures in the subcutaneous fat and another in the skin. No drainage is used.

(3) *Third Step of the Procedure—Closure of the Abdominal Wall Portion of the Gastrostomy* The edges of the former gastrostomy incision are excised. The fascia and peritoneum are identified, and a layer by layer closure of the small opening in the abdominal wall is brought about using interrupted fine chromic catgut sutures, with silk to the skin.

POSTOPERATIVE CARE

The patient's condition must be maintained during the first week or ten days after operation by means of the intravenous administration of solutions containing the necessary electrolytes, glucose, amino acids, and vitamins. Fluids may be allowed by mouth after five to seven days. By the end of 12 to 14 days the child should be able to take a diet suitable for his age.

Penicillin in doses depending upon the age of the child is administered until the danger of postoperative sepsis and pulmonary complications is over (approximately one week). The child should be kept in an oxygen tent during the first few days to ease the burden on the respiratory mechanism.

CASE REPORT

As an illustration of the utilization of this method of restoring continuity of the alimentary tract after the performance of a cervical esophagostomy and a gastrostomy the following case report is submitted.

W. C., a white male infant, age 21 months, was admitted to the Baker Memorial Unit of the Massachusetts General Hospital on June 19, 1947, referred by Dr. J. C. McCann of Worcester, Massachusetts. The history was as follows:

On the third day following birth it was discovered that the patient had a congenital tracheo-esophageal fistula. He was taken immediately to a children's hospital where he was operated upon. Through a right thoracotomy incision the fistula was closed and later a cervical esophagostomy and a gastrostomy were performed. After a stormy convalescence complicated by the occurrence of bilateral pneumonia and dehiscence of the gastrostomy wound requiring secondary suture the patient recovered and since then had developed at a normal rate. Although given to understand at first that a connection between the esophagus and the stomach would be made, the parents were finally told that it was not worth while attempting any further surgery. This decision was very disturbing to them because the child was eager to eat and swallow things and it was most pathetic to watch him when everything he took by mouth came out through the skin of his neck. They were anxious to undertake any risk whatever, no matter how great to make it possible for the child to eat in a normal fashion.

On examination at the time of admission to the Baker Memorial the child was a healthy appearing boy for his age. He walked normally but did not talk very much. A large catheter led into the stomach through a rather irritated-looking stoma which was in the center of a longitudinal abdominal incision through the left rectus muscle. In the left side of the neck about 2 cm. above the clavicle there was a cervical esophagostomy. The union of the esophageal mucosa to the skin was smooth. It was necessary to keep a dressing on the patient's neck at all times.

CONGENITAL ATRESIA OF ESOPHAGUS



FIG 5—Case W C Photograph taken three weeks after operation showing the closed gastrostomy incision in the anterior abdominal wall, the cervical incisional scar, and the anterior portion of the thoracotomy incisional scar

Barium given by mouth passed immediately into the dressing at the left side of the neck. Barium introduced through the gastrostomy tube did not pass up into the esophagus sufficiently far to demonstrate with certainty the lower segment, but there appeared to be approximately 6 cm of esophagus. Barium passed readily through the pylorus into the duodenum (Fig 4).

Laboratory examinations showed the urine to be light amber in color with an acid reaction and a specific gravity of 1.030. There was no albumin, sugar, diacetic acid, or bile. The sediment contained 4 white blood cells, 2 epithelial cells, and mucin. The white blood count was 8600, the photo hemoglobin 122 Gm. There were 57 polymorphonuclear leucocytes, 37 small lymphocytes, and 6 monocytes. The stained spe-



FIG 6—Case W C Photograph taken three weeks after operation showing posterior portion of the thoracotomy incisional scar. The scar of the previous thoracotomy on the right side shows in this view.

cimen showed a few polymorphonuclear leucocytes, moderate achromia and variation in size, and a rare stippled red blood cell. The platelets appeared fairly normal. The plasma protein was 6.7 Gm per cent. The prothrombin time was 17 seconds.

After ten days of observation and preparation for operation a transthoracic and trans-cervical partial esophagectomy with esophagogastric anastomosis was performed according to the technic already described. Postoperatively hydration and nutrition were maintained by continuous intravenous drip. This was accomplished with difficulty because of the small size of his veins and the fact that many of them had been used before. He took practically nothing by mouth until his fourteenth postoperative day. He then began to take food in small amounts but not sufficient for nourishment, so that a Levine tube was passed through the anastomosis into his stomach and he was fed by gavage until about the 20th day after operation when he began to eat normally. He lost about 4 pounds while he was in the hospital. After his mother had been instructed



FIG 7—Case W C Postoperative roentgenogram after ingestion of barium. The anastomosis is indicated by the arrow. Just below are the rugal folds of the fundus of the stomach. The remainder of the stomach as it lies in the left pleural cavity behind the hilum of the lung contains air and a small amount of barium. The cut ends of the first rib and clavicle are easily seen. The lung lies around and to the side of the stomach.

in his feeding and he was ready to go home, he had a gastro-intestinal upset which delayed his discharge from the hospital for about a week.

When the patient was brought to the office for a postoperative examination three weeks after leaving the hospital, he looked very well and, according to his mother, was eating a liberal diet in large quantities. The incisions were well healed. There was some ballooning out of the soft tissues at the base of the left side of the neck during inspiration. His weight was about the same as when he left the hospital, but he had apparently adjusted completely to conditions at home and was making steady progress. A more recent report from his physician states that the child is eating a diet normal.

for his age. The amount of food consumed is normal, but his weight gain has been slow. His stools are normal and there is no obvious evidence of physiologic disturbances resulting from the displacement of his stomach through his chest into his neck.

ADDENDUM.—Since this operation was performed, the same technique has been used for a subtotal esophagectomy and intracervical esophagogastric anastomosis in a case of carcinoma of the esophagus located in the region behind the manubrium of the sternum. No satisfactory procedure has been available previously for use in such cases. A growth at that level is too low for the Wookey operation,⁵ which can be applied only in cases where the tumor is in the cervical segment, and too high for the application of the operation of transthoracic esophagectomy with a high intrathoracic esophagogastric anastomosis.⁶ The patient, a man 56 years of age, has made an uneventful recovery and is eating in a normal fashion.

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- 3 Ladd, W. E. and O. Swenson. Esophageal Atresia and Tracheo-Esophageal Fistula. *Ann. Surg.* 125: 23-40, 1947.
- 4 Sweet, R. H. Subtotal Esophagectomy with High Intrathoracic Esophagogastric Anastomosis in the Treatment of Extensive Cicatricial Obliteration of the Esophagus. *Surg. Gynec. and Obst.* 83: 417-427, 1946.
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LETTER TO THE EDITOR

Dear Sir:

Dr. D. B. Phemister calls my attention to a bibliographic error in the December 1947 article by myself and coworkers on Hemorrhagic Shock. Reference #16 should read:

Phemister, D. B. and C. H. Laestar. Local Fluid Loss, Nerve Stimuli and Toxins in the Causation of Shock. *Ann. Surg.* 121: 803, 1945.

Phemister, D. B. The Mechanism and Management of Surgical Shock. *J. A. M. A.* 127: 1109, 1945.

Parsons, E. and D. B. Phemister. Hemorrhage and "Shock" in Traumatized Limbs. *Surg., Gynec. and Obst.* 51: 196, 1930.

Reference #7 should have in addition to the one given the following:

Phemister, D. B., C. H. Laestar, L. Eichelberger and R. J. Schachter. Afferent Vasodepressor Nerve Impulses as a Cause of Shock. *Ann. Surg.* 119: 26, 1944.

JACOB FINE, M. D.



TRANSACTIONS OF THE SOUTHERN SURGICAL ASSOCIATION

MEETING HELD AT HOLLYWOOD BEACH, FLA
DECEMBER 9-11, 1947

ANEURYSM FOLLOWING SURGICAL PROCEDURES*

Report of Five Cases

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IT IS GENERALLY RECOGNIZED that trauma is the *usual* causal agent in the production of an arteriovenous fistula, and the *most frequent* etiologic factor in the production of an aneurysm. However, it is not generally recognized that the trauma incurred in the performance of a surgical procedure or operation is an additional factor in the production of these lesions. Operative procedures have become so commonplace that safety factors which prevent serious complications are occasionally overlooked. The purpose of this report is to call attention to the possibility of arterial injury accidentally produced in the course of an operation, eventuating in an aneurysm or a fistula.

Accounts of injuries to blood vessels have been recorded since the beginning of medical history, and among the writings of Galen in the first century of the Christian Era we find descriptions of aneurysms produced accidentally in the course of bloodletting†. Although bloodletting has long passed into

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Tuesday, December 9, 1947

† "One of the earliest and most interesting references in literature is to an instance of this kind. Galen was called in consultation by a young and inexperienced surgeon who had opened the artery at the bend of the elbow instead of the vein, and the blood spurted out 'clarus, rubens, lucidus et calid' (See footnote continued on next page.)

Delays in the appearance of this and other recent issues of the ANNALS OF SURGERY have been due to present unsettled conditions in the printing trades. A return to original schedules is expected as soon as a settlement of these difficulties is reached.

oblivion, the re-introduction on a large scale of both venous and arterial puncture as a diagnostic and therapeutic measure will probably be followed by an increased number of aneurysms and fistulas

The early medical history of blood vessel injury, although primarily concerned with the arrest of hemorrhage and the use of ligatures, makes frequent mention of aneurysms. It was not until 1757, however, that William Hunter accurately described an arteriovenous shunt and its effect upon the local circulation. Hunter's two cases were both produced accidentally by bloodletting, it being supposed that the lancet puncturing the basilic vein pierced too deeply and injured the underlying radial or brachial artery at the same time.*

A survey of the literature reveals numerous reports of arteriovenous fistulas following surgical procedures. This lesion has been produced between the inferior vena cava and the right iliac artery during operation for ruptured intervertebral disk,¹ it has been seen in amputation stumps,² and in the uterine vessels following hysterectomy.³ Instances have been reported of intercostal arteriovenous fistula following thoracentesis⁴ of the facial vessels, caused by application of a Roger Anderson splint,⁵ of the anterior tibial vessels following introduction of a Steinmann pin,⁶ and of the superior thyroid artery following thyroidectomy.⁷ I have seen it in the posterior tibial vessels following introduction of a Steinmann pin, and in the genicular vessels following an operation for the removal of a semilunar cartilage, but as these two patients refused operation, they are not included in this report.

It is thus evident that an arteriovenous communication may be produced in any operation. It is most likely that the lesion is produced when vessels are transfixed and ligated, an artery and vein being injured simultaneously by the needle, and an opening made through which the communication is subsequently established. Although transfixion and ligation of a vessel are standard procedures, it should be remembered that mass ligation of arteries and veins may well give rise to this lesion (see Case 5). Particular care should be taken to avoid the inclusion of more than one vessel in a transfixion suture. In addition,

* Hunter's first case was published in *Medical Observations and Inquiries by a Society of Physicians in London*, in 1757 (Volume 1, page 323). His second case was reported in the same journal in 1762 (Volume 2, page 390). The exact time of his observation of these patients is unknown but is supposed to have occurred several years before the publication of the reports.

(Footnote continued from p 769) 'I took in the situation at once, there happened to be an elderly physician with me, so we prepared a medicine, viscid, conglutnable, and obstructive, and placing it strongly against the lips of the wound bound over it a soft sponge. The surgeon who had opened the artery wondered, but said nothing. When we went out [note the professional touch!] I said to the surgeon that he had opened the pulsating vessel, and charged him not to dress the wound before the fourth day, and not without me.'

"The cure was complete, and Galen remarks that this was his only successful case of the kind, as in all others aneurysm had followed." Sir William Osler, *Remarks on Arterio-Venous Aneurysm*. *Lancet*, Lond., 1, 949, 1915.

traction pins, wires, and fixation devices for immobilization of bones should not be inserted near the known anatomic course of blood vessels

In a personal series of approximately 650 operations for aneurysm and arteriovenous fistula, six definitely followed operation or some surgical procedure, and it may be presumed, therefore, that approximately one per cent of these lesions follows operative trauma. One of these cases has been previously reported,³ and this communication is concerned primarily with five additional instances of this lesion

Case 1—*SH, Hosp No 10123, soldier, age 30 False aneurysm, right brachial artery, lower third, following diagnostic venepuncture August 1944 Treatment by Matas endo-aneurysmorrhaphy, September 19, 1944 Recovery*

This 30-year-old soldier was transferred to the Army vascular center at Ashford General Hospital with a diagnosis of mycotic aneurysm of the right brachial artery. The patient had had bacterial endocarditis, and at the time of his transfer had mitral stenosis. The aneurysm had developed at least six weeks after his blood cultures were negative. Shortly before the aneurysm developed blood was drawn from the patient's arm in this region on numerous occasions. He complained of swelling of the right forearm of seventeen days duration, numbness of the first and second fingers, congestion of the hand on dependency, excessive sweating and loss of complete motion of the elbow.

Examination revealed a fusiform swelling of the upper right forearm on the anterior aspect. It was approximately 8 cm in diameter, and over it a faint thrill could be felt. The mass pulsated, and on auscultation a systolic bruit, not transmitted to the hand or the axilla, could be heard over it. There was congestion of the right hand and cyanosis of the nail beds on both sides. Both hands were mildly sweaty. Oscillometric readings at the wrists were normal, slightly higher on the left than on the right. Skin temperatures were excessively high on both sides. The Kahn test was negative. A diagnosis of false, traumatic aneurysm of the right brachial artery was made.

Endo-aneurysmorrhaphy (Matas) was performed September 19, 1944 under nitrous oxide, oxygen and pentothal sodium. Under a tourniquet, an incision was made just over the aneurysmal swelling, beginning at the crease of the elbow and extending down about 10 cm. The aneurysm was found to ramify deep in the muscles and between the ulna and radius. It was opened and a large clot evacuated. The appearance of the sac was that of a false aneurysm as seen following trauma. The lining was smooth, there was no evidence of infection, or of vegetations. An upper and lower opening in the wall of the artery could easily be seen, and these were closed with interrupted sutures of silk. After closure of the wound, an ace bandage was applied from the wrist to the midarm. The hand was warm, and there was good return of circulation after pressure on the fingers. The post-operative course was uneventful.

Case 2—*Ms MP, EU 1178, age 57 False aneurysm, left brachial artery, lower third, produced by incision of abscess forty years previously Treatment by excision, April 9, 1947 Recovery*

This patient had an abscess of the left arm and forearm when she was 18 years old, which was incised and drained. During a period of hospitalization in 1938, it was noticed that she had a mass in the left forearm near the elbow. The condition was entirely asymptomatic until the summer of 1946 when her left arm became weak and stiff after a period of carrying groceries. During the succeeding few months she had pain in her left arm, extending into the left shoulder region. This became more severe, and in January 1947 she noticed swelling of the left hand with occasional numbness and tingling.

Examination revealed an old operative incision on the anteromedial aspect of the left arm near the elbow, and a larger incision on the anterior surface of the arm at a slightly higher level. A firm, expansile mass was present, extending from just above the

antecubital fossa for a short distance inferiorly. A bruit, present only in systole, was heard over the mass. On palpation of the incision a defect in the underlying muscle and fascia was noted, and the pulsation of the brachial artery was readily detected. Slight pressure in this region obliterated the expansile pulsation. Oscillometric readings and skin surface temperatures were normal. There was no color change of the extremities on positional changes. Radial and brachial pulsations were normal. The Kahn test was negative. A diagnosis of arterial aneurysm, left brachial artery, lower third, was made (Fig 1).



FIG 1

FIG 2

FIG 1—Case 2. Preoperative photograph. False aneurysm of the brachial artery following incision of abscess.

FIG 2—Case 2. Postoperative photograph showing incision curved transversely across the antecubital fossa.

On April 8, 1947, excision of the aneurysm was performed under pentothal sodium, nitrous oxide and ether. A pneumatic tourniquet was applied to the upper arm. An incision was made longitudinally over the mass for about two inches and curved transversely across the elbow in line with the skin fold (Fig 2). A large number of superficial veins were divided and ligated. The mass was oblong, about 2 by 4 cm, its capsule was tough and could easily be dissected from surrounding structures. The proximal and distal arteries were ligated and divided, and the mass completely enucleated. The vessels were soft and showed no evidence of arteriosclerosis. The aneurysm was



FIG 3—Case 3 Preoperative photograph. False aneurysm of the external iliac artery following repair of hernia.

FIG 4—Case 3 Postoperative photograph showing incisions

lying directly on the median nerve, but this structure was not disturbed. After the wound was closed, an elastic bandage was applied from the finger tips to the midarm. There was no pulsation of the radial artery at the wrist following operation, but the hand was warm and the circulation in the fingers good. Recovery was uneventful. Examination of the specimen showed a typical false aneurysm with a smooth-walled, fibrous sac.

Case 3—C M, E U 1166-936, male, age 38. False aneurysm, left external iliac artery, following herniorrhaphy performed May 1946. Treatment by Matas endo-aneurysmorrhaphy, January 23, 1947. Recovery.

This man had a left inguinal hernia repaired on May 13, 1946. He was told after the operation that a blood vessel had been injured. His surgeon stated that he "encountered some bleeding when a stitch was placed to unite the conjoined tendon to the inguinal ligament, but the bleeding was easily controlled by a ligature." Two months following operation, the patient noticed in the left inguinal region a small, firm mass which gradually increased in size over a period of about four months, and then suddenly enlarged causing severe pain in this region. Two months prior to admission to the hospital in January 1947, a smaller mass developed at the inferior limit of the first one. There was no further progression in the size of either. The patient complained of pain in the left inguinal region on exercise. There was no weakness, claudication, or swelling of the extremity.

Examination revealed a lobulated, pulsating mass, approximately 12 cm in diameter, under a left inguinal incision (Fig 3). At the inferior limit of this mass was a smaller mass measuring 2.5 cm in diameter. A systolic bruit with a slight pause and a diastolic murmur were audible. The murmur was not continuous, nor was it transmitted beyond the confines of the mass. The veins of the extremities were not enlarged. The lower extremities were equal in size and without abnormal color changes, ulceration or pigmentation. There were no color changes on positional maneuver. There was moderate sweating of both feet. Skin surface temperatures of the toes of both feet were moderately reduced but equal bilaterally. The right dorsalis pedis pulsation was faint, the left was absent. Oscillometric readings were bilaterally equal, symmetrical and normal. The Kahn test was negative. A diagnosis of arterial aneurysm of the left external iliac artery was made.

On January 23, 1947, under continuous spinal anesthesia, a sympathectomy was performed prior to the operative repair. A low abdominal incision was made, the peritoneum was reflected medially without opening it, and the common iliac artery was exposed. The lumbar sympathetic chain was exposed and the third ganglion removed. A clamp was placed on the common iliac artery temporarily to occlude it.

A longitudinal incision was then made directly over the aneurysm which pointed under Poupart's ligament (Fig 4). The sac was opened and a large clot removed. Bleeding was brisk but the opening was found and could be controlled by occlusion with a finger. The opening itself was closed with four interrupted sutures of silk. There was considerable oozing from the wound which probably indicated a good collateral circulation. At the end of operation, the patient's foot was warm and pink, and the color returned rapidly after pressure. Recovery was uneventful.

Case 4—Mrs E B, GR A132223, age 44. Arteriovenous fistula, right facial vessels following injection of procaine thirty years previously. Treatment by quadruple ligation and excision of fistula, October 15, 1946. Recovery.

This patient reported September 27, 1946 because of a tumor on the right side of her jaw. Her dentist had refused to pull a tooth until the tumor was removed, for fear of hemorrhage. The patient gave a history of having had a right lower molar extracted when she was twelve years old. Procaine was injected prior to extraction of the tooth. The tumor, which was about the size of an acorn and of bluish color, was first noticed when the swelling following extraction subsided. Since that time it had slowly grown to about 3 cm in diameter.

Examination revealed a bluish streak, 3 cm wide, extending from the right corner of the mouth down across the angle of the jaw and terminating over the bifurcation of the carotid artery. Slightly above the streak where the facial artery crossed the mandible, there was a soft, nontender mass about 3 by 4 cm in diameter. This could be collapsed on pressure, but refilled rapidly. There was continuous thrill and bruit, accentuated in systole, over the entire mass. The pulse rate was 88, and the heart sounds were of good

quality with no irregularities or murmurs. A diagnosis was made of arteriovenous fistula, right facial artery and vein at angle of the mandible (Fig 5).

On October 15, 1946, under intratracheal nitrous oxide, oxygen and ether anesthesia, operation was performed. A linear incision about 5 cm long was made transversely below the lower border of the mandible on the right side, beginning just anterior to the angle and extending forward. As it was impossible to isolate the main proximal and distal vessels to the fistula, the mass was enucleated. The proximal and distal arteries and veins, together with the collateral vessels, were ligated and divided. The wound was closed and a pressure dressing applied. Recovery was uneventful (Fig 6).



FIG 5—Case 4. Preoperative photograph. Arteriovenous aneurysm of the facial vessels following procaine injection.

Case 5—SV, EU 167-273, male, age 50. Arteriovenous aneurysm, right renal vessels, following nephrectomy for tuberculosis in 1926. Treatment by ligation of right renal artery, February 11, 1947. Recovery.

A printer, age 50, had had his right kidney removed in 1926 because of tuberculosis. His surgeon stated later that the operation was performed in a routine manner and that no unusual difficulty was encountered. He further stated that it was possible that the artery and vein had been ligated en masse. His recovery was uneventful, and he left the hospital on the sixteenth postoperative day. For ten years he had suffered from shortness of breath, and in 1943 he began to have a feeling of oppression and constriction in his chest, which awakened him at night. This was diagnosed as pericarditis, and he was placed in a hospital for a week. His tolerance for activity decreased, and he became so short of breath that he had to sit up in bed to sleep comfortably. He

complained of increasing weakness, nervousness, and periodic headaches. In December 1945 he again was in the hospital for three days because of a friction rub over the left lower lobe of the lung which was treated with penicillin. He had recurrent bouts of pleuritic pain, and over a three-year period on occasion coughed up bright red blood. In 1946 he became conscious of a thumping sensation in his arms and neck when he sat on a hard chair. During a physical examination in December 1946, his physician (Dr. Mason I. Lowance) noted a loud, rough murmur over the region of the flank wound. At this time moderate cardiac enlargement was noted.

He was admitted to the hospital January 29, 1947. Examination revealed a healed right flank wound over which a loud continuous bruit, accentuated on heart beat, could



FIG 6—Case 4 Postoperative photograph after excision of arteriovenous aneurysm

be heard. The heart showed marked left ventricular enlargement, the sounds were loud, and a systolic murmur was heard at the apex. There was an increase in blood volume of approximately 450 cc above the normal level. A diagnosis of arteriovenous aneurysm of the right renal vessels was made.

Operation was performed February 11, 1947 under nitrous oxide and ether anesthesia. A transverse incision was made, beginning at the costal border on the right, and carried directly across the abdomen, dividing both recti muscles (Fig 7). The peritoneum was opened without difficulty. The liver was considerably enlarged. Just to the left of the vena cava, a distinct thrill could be felt. This region was exposed by opening the peritoneum along the right lateral border of the duodenum and reflecting the duodenum to the left, completely exposing the vena cava and the right kidney fossa (Fig 8). The vena cava was greatly enlarged, perhaps three or four times its normal size, and was

covered with a network of greatly dilated veins thought to be the venae comites. Just to the right of the vena cava there was a soft knob-shaped protrusion, evidently the end of the renal vessels. This was the point of maximum thrill. The thrill could be obliterated by pressure on this point, and the opening between the artery and vein, about the size of the tip of the finger, could be felt. It was believed that the shunt of the blood from the stump of the renal artery into the stump of the renal vein was the cause of the great enlargement of the vena cava and of the dilated venae comites. An effort was made to dissect the stump of the renal artery free from the stump of the renal vein, but this was discontinued since it was evident that the accidental opening of the vein might lead to rapid and fatal hemorrhage. Therefore, the vena cava was separated from the aorta and the right renal artery was isolated as it passed behind the vena cava. This artery

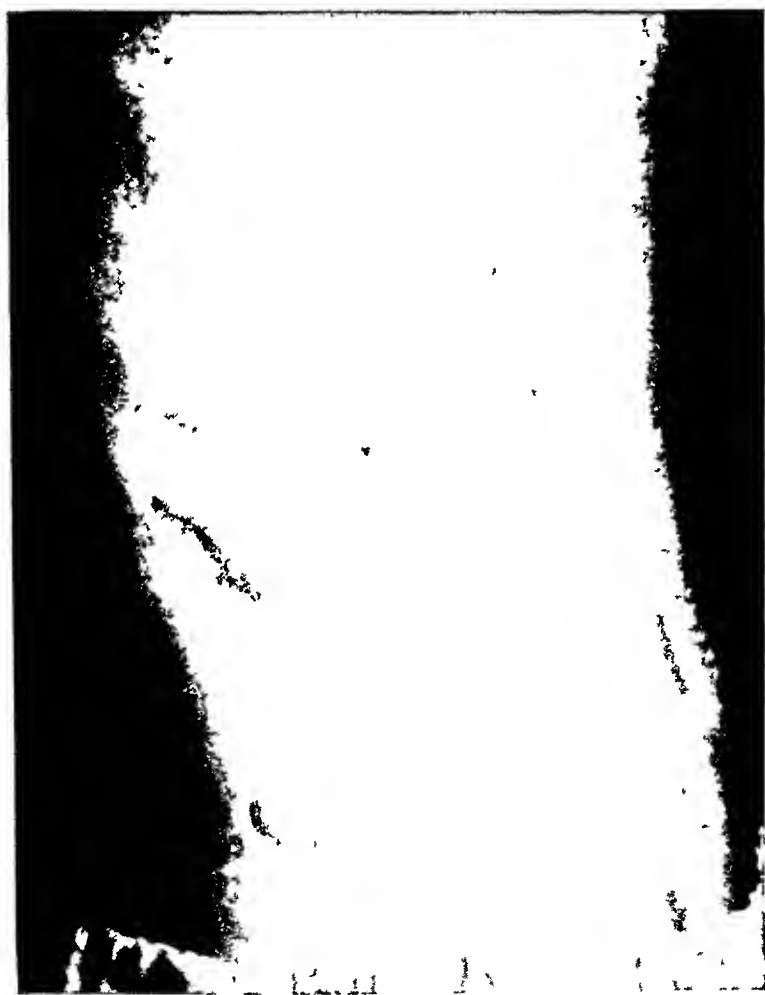


FIG 7—Case 5 Postoperative photograph showing transverse incision

was enlarged to about twice its normal size. It was doubly ligated with medium braided silk, the ligatures being placed about 1 cm apart. The thrill immediately disappeared, and it was believed that this would cure the condition since there are no branches of the renal artery.

Observations were made during the course of the procedure. The blood pressure, which before operation was usually 180/70, fluctuated considerably, perhaps due to interference with the splanchnic nerves in this region. On compression of the fistula, there was a drop in pulse of twelve beats per minute, and the diastolic pressure rose to 100 mm of mercury and remained at that level. He withstood the operation well, and his recovery was uneventful.

He has been examined on several occasions since the operation, but the enlargement of his heart has persisted and the symptoms of cardiac failure, as evidenced by dyspnea, have remained. It is believed that his cardiac failure resulted from the presence of this large arteriovenous shunt over a period of 21 years, so affecting his heart as to produce irreversible damage. There has been no return of the bruit.

SUMMARY

In a series of approximately 650 operations for aneurysm and arteriovenous fistula, six have been encountered which were believed to be the direct

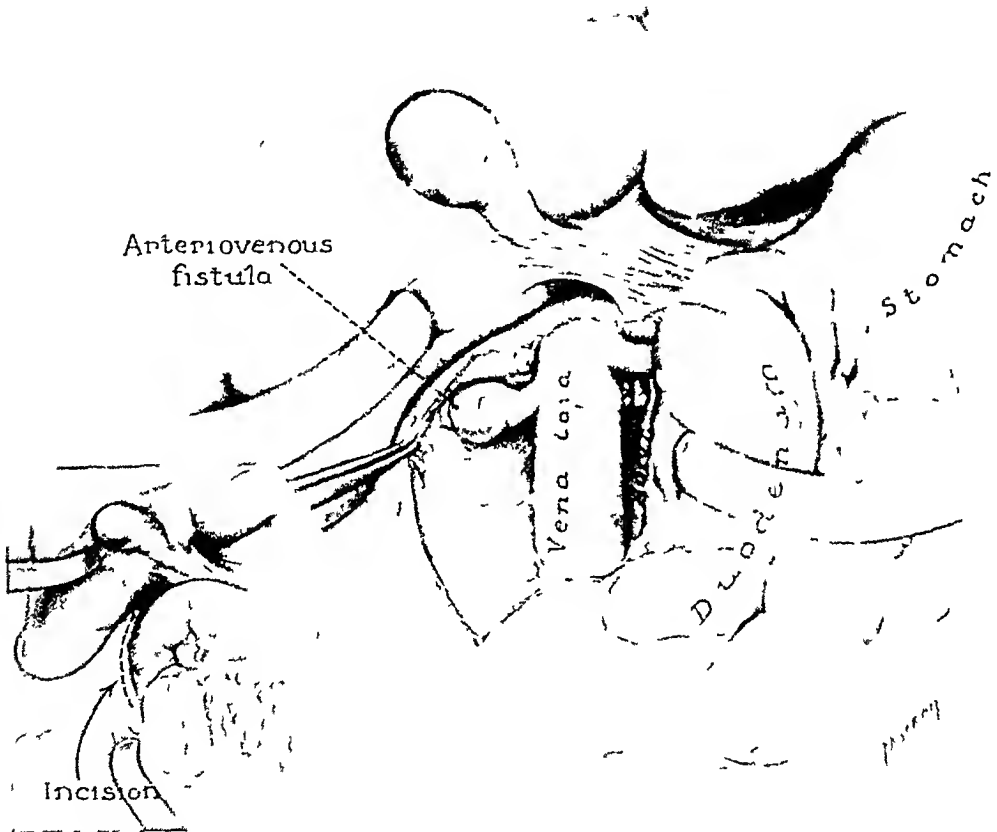


FIG 8—Case 5. Arteriovenous fistula in stump of renal vessels. Treatment by double ligation of the renal artery. Insert shows line of incision for mobilization of duodenum and exposure of renal fossa.

result of accidental injury of a blood vessel during the course of an operative procedure. One of these was previously reported.

The history of five additional cases is reviewed with description of the location of the lesion, type of injury, and the treatment.

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ANEURYSM OF THE LEFT COMMON ILIAC ARTERY SECONDARY TO A TRAUMATIC ARTERIOVENOUS FISTULA OF THE LEFT POPLITEAL VESSELS*

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THERE HAVE BEEN NUMEROUS REPORTS of tremendous dilatation of an artery proximal to an arteriovenous fistula. Likewise there have been a few reports of an aneurysm developing in an artery proximal to an arteriovenous fistula. Since this latter complication with respect to an arteriovenous fistula is infrequent, an additional case with reference to several interesting features is submitted.

CASE REPORT

R G A colored male, age 61, first came under my observation on April 9, 1946, complaining of weakness and nervousness.

Past history—At the age of 18 (43 years ago) he was shot through the left leg with a .38 caliber pistol. The bullet entered the leg posteriorly at the lower level of the knee and made its exit anteriorly just below the patella. Since that time he has complained of a pulsating mass in the left popliteal space and swelling of the left lower extremity. Large varicose veins have been present in the involved extremity for the past 35 years, extending up to the left groin. A varicose vein of the left leg ruptured 25 years ago following exertion and caused a severe hemorrhage. A hematoma developed and was incised and drained, requiring 8 months' bed rest before the resulting ulcer healed. A large pigmented area on the anterior surface of the leg has been present since that time. The patient has worn a supporting bandage on the left leg for the past 25 years. He has continued to complain of impaired circulation in the left leg. In recent years he has developed mild dyspnea on exertion and palpitation of the heart. Epigastric discomfort has been present for the past 6 months.

He gave no history of syphilis and stated that repeated "blood tests" have been negative. One year ago he first noticed a pulsating mass in the left lower abdominal quadrant, which has grown progressively larger but has caused him no apparent discomfort. No history of frank left or right sided heart failure was obtained. His weight has decreased from 203 to 161 pounds in the last year.

Physical examination—The patient showed evidence of moderate weight loss. Blood pressure was 140/70. The pulse rate was 76. There were frequent premature beats. The heart was enlarged 3 cm beyond the normal limits. Aortic and mitral systolic murmurs were present.

Abdominal examination revealed a large expansile, pulsating mass in the left lower quadrant corresponding with the location of the left common iliac artery. The mass was approximately the size of a grapefruit, measuring 10 cm x 12 cm. On auscultation a loud systolic bruit could be heard over the mass.

The left lower extremity was considerably larger than the right. Large varicosities were present from above Poupart's ligament down to the ankle. The leg showed edema and induration of the soft tissues with extensive pigmentation and scarring from previous ulcerations.

Examination of the popliteal space revealed a large pulsating mass measuring approximately 8 cm x 12 cm and filling the entire space. A thrill could be felt over the mass. On auscultation a loud continuous bruit could be heard with greatest intensity

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Tuesday, December 9, 1947.

over the popliteal space but extending well onto the thigh and the leg. By palpation the femoral artery was found to be dilated.

Obliteration of the arteriovenous fistula by digital pressure produced a slowing of the pulse rate from 72 to 56 per minute (positive Bianham's sign) and an elevation of blood pressure reading from 120/50 to 170/90. There was no clinical evidence of diminished circulation in the involved leg or foot following obliteration of the fistula.

Hemoglobin was 78%, erythrocyte count 3,980,000 and the leucocyte count 5,100. Urinalysis was negative. The blood Wassermann was negative. Roentgen-ray examination of the chest revealed definite cardiac enlargement. Electrocardiographic interpretation May 6, 1946, by Dr. John B. Burrett, revealed a borderline tracing compatible with myocardial damage. It showed auricular bigeminy, auriculoventricular and intraventricular conduction duration at upper limit of normal (0.2 and 0.10-0.11 seconds respec-



FIG 1—A Anterior view before operation showing enlargement of the left lower extremity, varicosities and extensive pigmentation of the leg. B Lateral view of the left leg showing prominence of the popliteal space at the site of arteriovenous fistula.

tively), prominent Q in C F 4, 5 and 6. Subsequent electrocardiograms (following operation) have shown no significant change from that described above except that in one taken recently premature beats were no longer present.

Diagnosis—(1) Arteriovenous fistula of the left popliteal vessels of 43 years' duration. (2) Large fusiform aneurysm of the left common iliac artery secondary to the popliteal arteriovenous fistula.

After consultation with Drs. J. M. Mason and D. C. Elkin, it was considered advisable to operate on the arteriovenous fistula with the hope of improving the status of the iliac aneurysm, the heart and the circulation in general.

The patient was admitted to South Highlands Infirmary on May 29, 1946. The Matas

test proved the circulation to be adequate when the fistula was obliterated. The patient was instructed to obliterate the fistula at frequent intervals in order to accommodate the cardiovascular system to the changes incident to elimination of the fistula.

Operation June 3, 1946. Sextuple ligation (popliteal artery and vein proximally and anterior and posterior tibial arteries and veins distally) and complete excision of the arteriovenous fistula.

Under spinal (pontocaine) anesthesia, a tourniquet was applied to the upper thigh

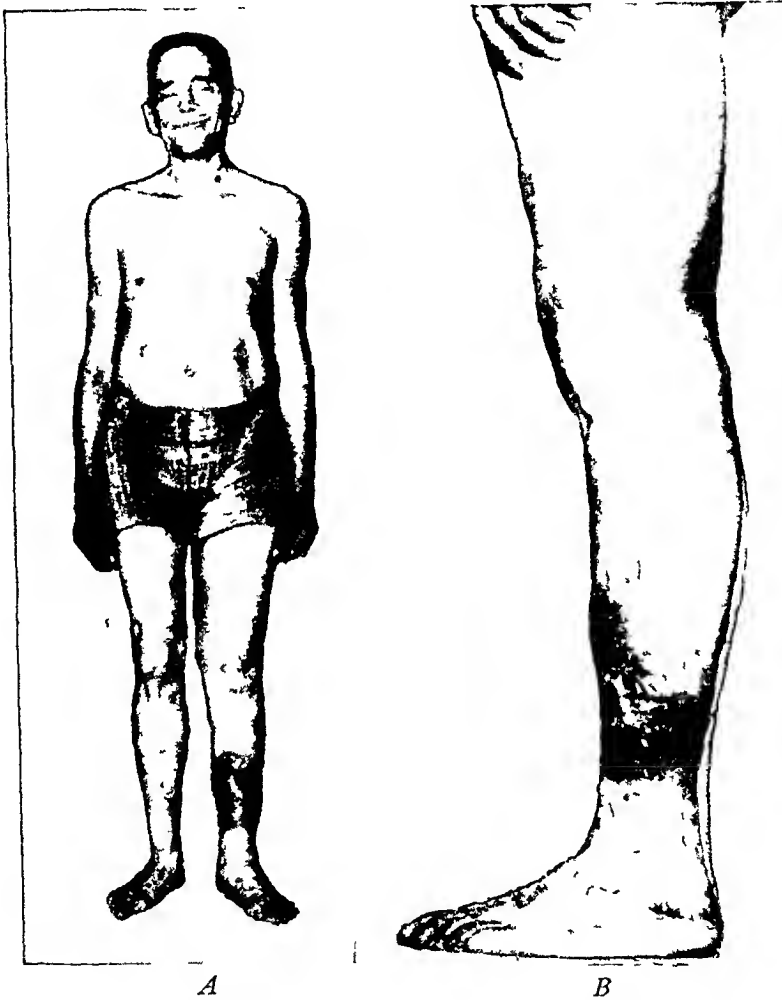


FIG 2—A and B Anterior and lateral views made 18 months after operation showing a decrease in the size of the left lower extremity and less evidence of varicosities

The patient was placed in the prone position and an incision 20 cm in length was made over the popliteal space. The common peroneal and tibial nerves were dissected free of the aneurysm and were retraced laterally. A large saccular arteriovenous aneurysm was found filling the popliteal space. It measured 8 cm in width and 12 cm in length. The popliteal vein was 5 cm in diameter. The popliteal artery was thinner than normal and was densely adherent to the vein. The artery proximal to the fistula was dilated to 1.5 cm in diameter and thin walled. The fistula was present just at the level of bifurcation of the popliteal artery. The anterior and posterior tibial arteries were found to be larger than normal. It was impossible for me to separate the artery and vein at the site of the fistula. After ligating the popliteal artery and vein proximally and the anterior and



FIG 3—Posterior view after operation showing the relative size of the two extremities and the line of incision

posterior tibial arteries and veins distally with heavy silk, the intervening segment, including the fistula, was excised. A penrose drain was inserted and the wound was closed, obliterating the dead space as much as possible.

At the end of the operation the blood pressure reading was 150/110. The pulse rate was 90 and the rhythm was regular, whereas before the operation many extra systoles were present. The left foot and leg were as warm as the right. The pulsations and bruit in the iliac aneurysm were definitely diminished in intensity. No pulsation could be felt in the left posterior tibial or dorsalis pedis arteries either before or after operation.

The specimen measured 13 cm \times 6 cm. In the middle there was a fusiform enlarged portion measuring 6 cm \times 4 cm, which proved to be the popliteal vein. The vein wall was tough and irregularly calcified. Several saccular swellings arose from the popliteal vein opposite the fistula. There was considerable fibrosis of the walls of the artery but this was more marked in the vein. The fistula was located at the level of the bifurcation of the popliteal artery and apparently involved its anterior and posterior tibial branches at the site of the communication with the popliteal vein. The fistula was approximately 1 cm in diameter.

Postoperative course—The patient developed a low grade infection in a hematoma of the wound. The penrose drain may have been a factor in this complication. There was an associated mild cellulitis of the thigh just above the wound. The wound continued to drain until all silk sutures were recovered. The circulation has remained good in the left foot and leg following operation. There has been a progressive decrease in the size of the iliac aneurysm. Six foot chest roentgenograms show definite decrease in heart size following operation.

The last examination on November 12, 1947 (18 months after expiration of the arteriovenous fistula) revealed the iliac aneurysm to be reduced to 1/3 its original size. The bruit over the aneurysm is very faint. The left femoral artery remains somewhat dilated but has diminished in size. There is no clinical evidence of heart disease. The circulation distal to the site of the arteriovenous fistula is better than before operation. The patient has gained 50 pounds and is working regularly. The left thigh, though smaller than before operation, remains larger than the right and the patient has continued to wear a bandage on the left leg to control oedema. Blood pressure was 140/90. The pulse rate was 76 and was regular in rhythm.

COMMENT

In an admittedly incomplete review of the literature there have been nine cases of this particular complication reported.¹⁹ It is only in arteriovenous fistulae of many years duration (13 to 40 years in this series) that these proximal arterial aneurysms have been observed.

William Hunter¹⁰ in 1762 was the first to accurately describe an arteriovenous fistula. Since that time outstanding contributions by Matas, Reid, Callander, Holman, Mason, Pemberton, Bigger, Gage, Elkin and others have emphasized the serious systemic or cardiovascular effects of an arteriovenous fistula and have developed adequate methods of treatment. This discussion

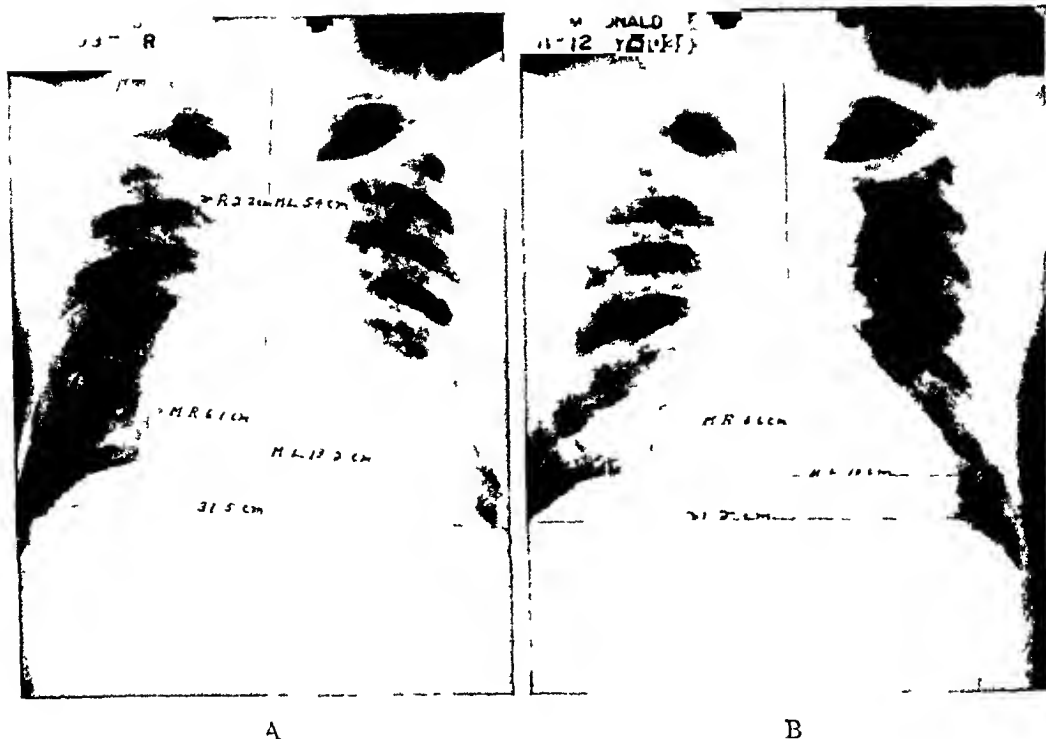


FIG 4—A Roentgenogram of the thorax made before operation showing enlargement of the heart B Roentgenogram made after operation which reveals definite decrease in the size of the heart This decrease in size occurred within a few weeks following operation and has remained this size

will be limited chiefly to the effects of an arteriovenous fistula on the proximal artery and more specifically to aneurysm of the proximal artery

In the article referred to above, Hunter likewise called attention to dilatation of the artery proximal to an arteriovenous fistula In describing this finding in a case of arteriovenous fistula of the brachial vessels he stated "A little above the bend of the arm the artery makes a remarkable serpentine turn which raised up the skin and by force of the pulsation looks as if it was a beginning aneurysm The artery at the wrist is much smaller and its pulsations much weaker than that of the opposite side"

Callander¹¹ in 1920 analyzed 447 cases of arteriovenous fistula and found a record of proximal dilatation of the artery in 57 cases (127%) The artery distal to the fistula was usually contracted In only 3 instances in this large series was the distal artery found to be dilated Reid¹⁴ observed dilatation of the distal artery in one of his cases The distal arteries in the present case were larger than normal

Matas¹² found notable enlargement of the artery proximal to the fistula in the majority of his long standing cases In several instances the thoracic aorta participated in the arterial enlargement Matas¹³ further stated that the enlargement of the artery on the proximal side of an arteriovenous fistula and increase volume of blood that flows through it is but an effort to compensate

for the relative ischemia of the tissues below the fistula and that the enlargement of the artery is directly proportional to (a) the size of the fistula (b) the volume of arterial blood that is short circuited into the veins at the fistula and (c) the duration of the fistula

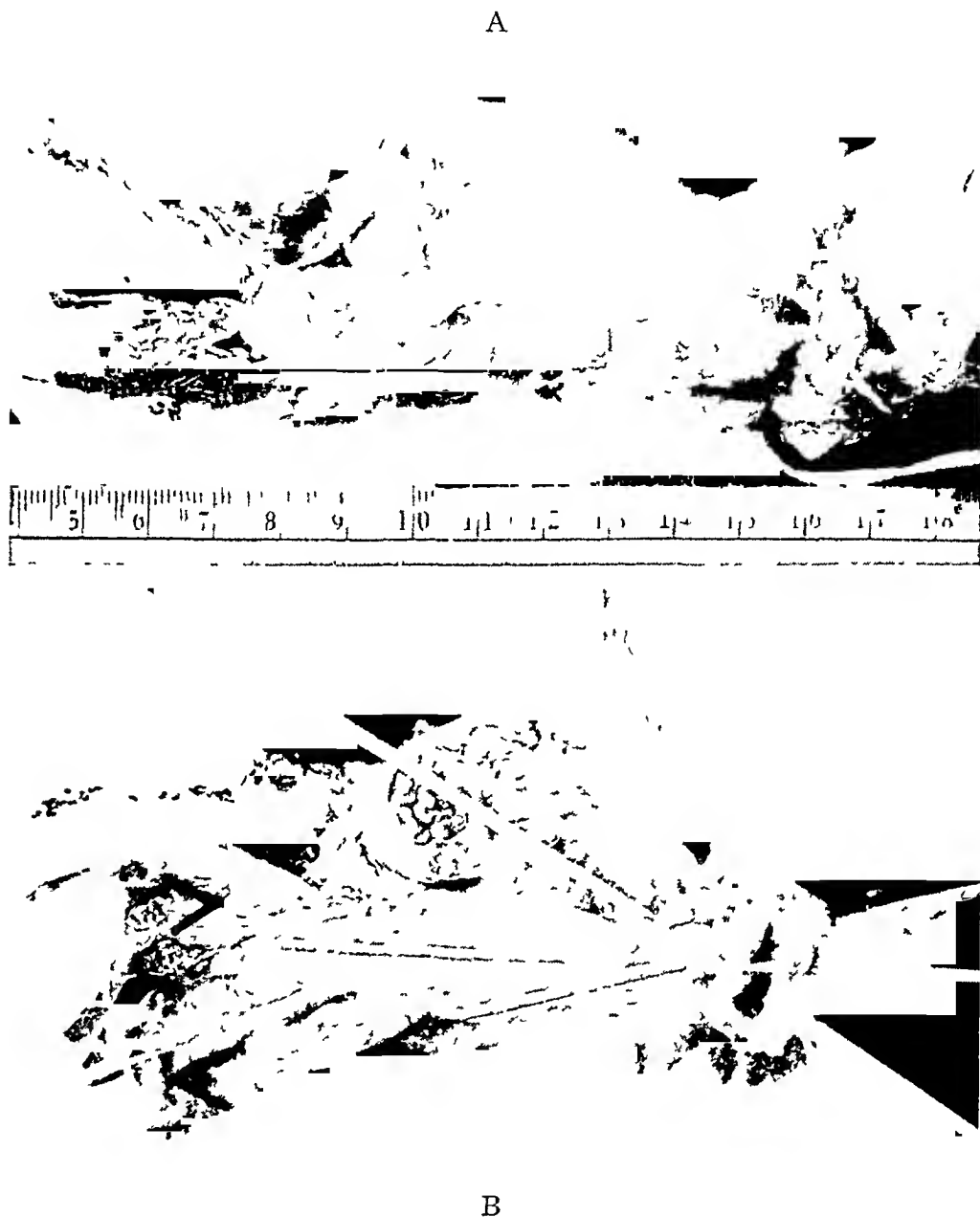


FIG 5—Excised segment of popliteal artery and vein containing fistula A Unopened specimen showing fusion of artery and vein and sacculation of the popliteal vein B Specimen opened to demonstrate fistulous communication between artery and vein Note extensive calcification in the popliteal vein

Reid¹⁴ observed that a fistula between an artery and vein leads to definite changes in the vessels. The arteries proximal to the fistula become dilated and thin walled and often show marked degenerative changes. The veins dilate and their walls may become thickened. He suggested that the alterations in pulse pressure might be responsible for the atrophy of the artery and hyper-

trophy of the vein. He further suggested that some alternation in the nutrition of the vessel walls might be a factor in these changes.

Holman¹⁵ explained the cardiac enlargement and the dilatation of the proximal vessels associated with an arteriovenous fistula on purely mechanical

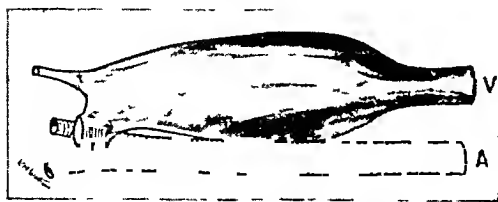


Fig 6—Drawing to demonstrate site of fistula at the bifurcation of the popliteal artery. The dilated fusiform vessel represents the popliteal vein.

and physical grounds. The area of lowered resistance produced by the fistula results in the establishment of two routes for the passage of blood: (1) through the normal capillary bed back to the heart, (2) through the fistula back to the heart. A greater volume of blood will be directed toward the fistula than toward the capillary bed, and this greater flow of blood produces the dilatation of the vessels leading to and from the fistula.

Just as the vessels respond to the greater volume of blood passing through them, so will the heart dilate to accommodate the increased flow through its chambers. The amount of blood short circuited will depend upon the size of the fistula and upon the unobstructed return flow to the heart. Holman reports a case of a large arteriovenous fistula of the femoral vessels of 26 years' duration with marked dilatation of the heart and proximal vessels in which there was almost complete disappearance of the dilatation following quadruple ligation and excision of the fistula. He believed that circulatory changes are dependent primarily upon the size of the fistula and upon an unobstructed return flow to the heart, and that the duration of the fistula is a factor of minor importance. Holman¹⁶ further explained the physiologic effects of an arterio-

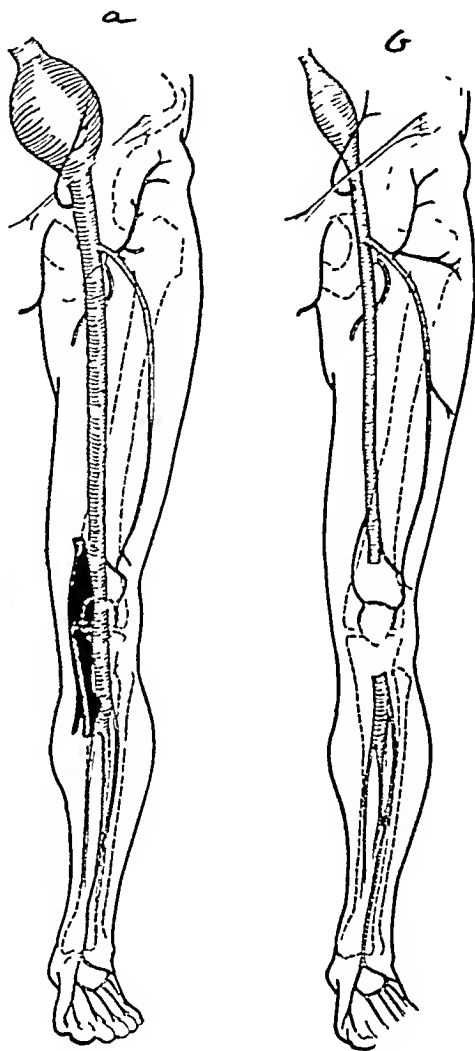


FIG 7—A Drawing to illustrate the size of the iliac aneurysm and the femoral artery proximal to the arteriovenous fistula. A segment of the popliteal vein at the site of the fistula is included in the drawing.

B Drawing to illustrate the reduction in size of the iliac aneurysm and the femoral artery following extirpation of the fistula.

venous fistula by considering the short circuit to the heart as a new circulation parasitic upon the normal circulation

Pemberton¹⁷ in a discussion of the degenerative changes in the artery proximal to an arteriovenous fistula called attention to the increased intra-arterial pressure and weakened arterial wall as rendering conditions ideal for the production of an aneurysm and warns that this danger must be thought of as a potential complication in all neglected cases of arteriovenous aneurysm

Elkin⁹ has pointed out that the improvement of an aneurysmal dilatation in the proximal artery after elimination of the arteriovenous fistula will depend upon the amount of damage which has already taken place in the artery and that this damage may be irreversible

Reid⁶ and Neuhoof⁸ each reported a case in which an aneurysm developed in the proximal artery several years after the arteriovenous fistula had been eliminated. In Reid's patient the fistula of the femoral vessels in Hunter's Canal had been present for over 30 years. The artery was dilated from the fistula back to the heart. At operation Dr. Halsted separated the artery and vein at the fistula and then reestablished continuity of both vessels. Six years later a large true aneurysm developed in Scarpa's triangle. In the case reported by Neuhoof a large dissecting aneurysm of the left iliac artery developed nine years after quadruple ligation and excision of an arteriovenous fistula of the left femoral vessels by Dr. Pemberton. This arteriovenous fistula had been present for 31 years.

In the case herein reported the popliteal arteriovenous fistula had been present for 42 years before the iliac aneurysm made its subjective appearance. Although the size of the fistula was relatively small (approximately 1 cm in diameter) the patient had exhibited all the local signs of an arteriovenous fistula (varicosities, trophic ulcers and deficient circulation of the leg) for many years before obvious systemic effects became manifest (enlargement of the heart, incipient cardiac decompensation, dilatation of the proximal artery and aneurysmal dilatation of the iliac artery). The iliac aneurysm in this patient is considered to be a direct result of the arteriovenous fistula for the following reasons: (a) It developed in the artery proximal to the fistula. (b) There has been no history of a syphilitic infection. (c) There was marked diminution in size of the aneurysm following extirpation of the arteriovenous fistula.

This case tends to confirm the observation of Matas¹³ that the duration of an arteriovenous fistula, as well as the size, is an important factor in the production of dilatation of an artery proximal to an arteriovenous fistula.

SUMMARY

A case of traumatic arteriovenous fistula of the popliteal vessels of 43 years duration is reported. A large, true aneurysm of the iliac artery proximal to the fistula developed several years after the onset of the fistula. The femoral artery was dilated from the fistula to the aneurysm. The heart was enlarged and there was evidence of myocardial damage.

Following sextuple ligation (popliteal artery and vein proximal to the fistula and the anterior and posterior tibial arteries and veins distally) and excision of the fistula, there was prompt reduction in the size of the iliac aneurysm. Six months after operation the aneurysm had reduced to $\frac{1}{3}$ its original size and the systolic bruit was only faintly audible. The heart has definitely decreased in size as demonstrated by roentgen-ray. There has been no evidence of cardiac decompensation and the circulation in the involved leg has shown decided improvement. Examination 18 months after operation revealed no significant changes in the findings noted above.

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DISCUSSION—DR EDWARD F PARKER, Charleston, S C We wish to congratulate the speakers, and Doctor Blakemore* in particular on his most ingenious and brilliant method of dealing with such a difficult lesion as aneurysm of the aorta.

Recently we were faced with the problem of having to deal with a large luteic saccular aneurysm of the mid-descending portion of the thoracic aorta. The wall of the

* Dr Blakemore's paper "Surgical Aspects of Aneurysm of the Aorta" will appear in the Southern Surgical Transactions, Vol 59, 1947

aneurysm was already badly torn, and a fatal hemorrhage was imminent. We did not have the equipment described by Doctor Blakemore, and therefore decided to try complete double ligation of the aorta in stages, with the ultimate goal that of complete excision of the aneurysm and the intervening segment of aorta involved. Though we did not meet with success, we feel that it is of interest to report the case.

The patient was a 38-year-old Negro. He looked perfectly healthy, but had been spitting up blood four or five times a day for the previous eight months. In the week before admission to the hospital he had had two very massive hemoptyses, during the second, he said that he spit up at least a quart of blood. X-rays of the chest (slides) showed a large rounded mass in the region of the hilum of the left lower lobe. On fluoroscopy, the mass did not appear to pulsate and, in particular, no expansile pulsation could be noted. Other studies which were done shed no light. We did not know what it was, thought it likely that it was carcinoma, and did an exploratory thoracotomy on the 5th of November of this year.

As soon as the left chest was opened it was apparent that the mass was an aneurysm of the aorta as it had an expansile pulsation which could be felt through the overlying adherent lung. The lung was freed from it with difficulty, as it had eroded the lung (slide). In doing this, the wall of the aneurysm was torn (slide) so that the lamellated clot was exposed. Why the aneurysm did not bleed at that moment we will never know, but it did not. Therefore, we decided to do a proximal ligation of the aorta, and occluded the aorta just above the aneurysm, about 70 per cent. This was done with two ox fascia ligatures tied over a tape of cellophane (slide).

Following operation, tests for renal function were normal. The patient complained of coldness of the feet for several days, but then subjective warmth returned. Even so, his feet remained rather ischemic although both dorsalis pedis pulses were present but weak immediately following operation. A mild hypertension persisted only a few days. On the 13th postoperative day he died of rupture into the left pleural cavity after the induction of anesthesia for a second-stage distal partial ligation, but before the operation could be carried out.

Autopsy showed grossly normal kidneys, liver and heart. The ligatures on the aorta were intact, and the lumen was constricted an estimated 70 per cent (slides).

Even though Owings and Hewitt were successful in only four out of 79 experimental animals in double ligation and division of the aorta, we still wonder if such would not be successful in the human if one could work under conditions not threatened by imminent rupture with fatal hemorrhage. We would like to have Doctor Blakemore's opinion on this.

DR ALLEN O WHIPPLE, New York. I cannot let this opportunity pass without expressing my appreciation of the work of Arthur Blakemore. He has spoken here about the stress and strain on the aneurysmal sac, but has not mentioned that on Arthur Blakemore. He worked with a method which theoretically was very complicated. His operating room for the years I was there looked like a physicist's laboratory, and he accomplished things against a great deal of difficulty. He was working in what was considered a hopeless field, and has done what he has reported without mention of the stress and strain on himself. I think it is because of his coming from old Virginia stock—they are very hardy.

DR BARNY BROOKS, Nashville, Tenn. I cannot resist the temptation to compliment Doctor Elkin for calling attention to the fact that accidental injury of a large artery in the course of a surgical operation is too frequently the cause of an arterial aneurysm and mass ligation of a large artery and vein may result in an arteriovenous fistula. I can recall having operated on two arterial aneurysms of the common femoral artery produced by accidental injury in the course of an operation for inguinal hernia, and one relatively large arteriovenous fistula from mass ligation of the femoral artery and vein from thigh amputation.

Concerning Doctor Donald's paper, I would seriously question whether the enlargement of the common iliac artery was in reality an arterial aneurysm. The fact that the pulsating tumor diminished in size after closure of the arteriovenous fistula of the popliteal vessels makes it more likely that the condition, believed to be an arterial aneurysm, was in reality the great dilatation and tortuosity which occurs in an artery proximal to an arteriovenous fistula of long duration. It is also interesting to point out that operations for subclavian aneurysm have been performed in instances of a similar dilatation which takes place in an artery just distal to a partial obstruction by a cervical rib.

Doctor Blakemore's presentation is a remarkable demonstration of what can be accomplished for the relief of arterial aneurysms near the base of the heart, where it appears unlikely that extirpation or the Matas operation can ever be applied. One cannot help but wonder if the excellent results obtained by Doctor Blakemore are not due to his careful study of patients before treatment, and thus his ability to obtain clotting at the most favorable site, rather than because of his modification of the Moore-Corradi method introduced many years ago. The remarks of Doctor Whipple support this idea.

DR J M T FINNEY, JR, Baltimore. In line with Doctor Elkin's paper, I felt it might be worth while to speak of a traumatic aneurysm for which I think I was responsible. This occurred in operating on a rather obese woman about 50 years of age for an acute gallbladder, through a subcostal incision, using a Deaver retractor with a rather sharp edge. The operation went along all right, it was a red hot gallbladder, which we removed with some difficulty, and we thought everything was all right. She was a chronic complainer and very nervous, and three or four times she complained of severe pain in the right flank for which we could find no reason. There was nothing in the urine, no elevation of temperature or pulse. On the 12th postoperative day she suddenly went into collapse and died before anything could be done.

At autopsy we found a tremendous retroperitoneal hemorrhage and the pathologist demonstrated a traumatic aneurysm of the right renal artery, apparently where it had been pinched by the Deaver retractor against the vertebral bodies. I do not know how common such an accident may be, but in looking back and considering how easily such a thing could happen, I wonder that it has not occurred more frequently than reports in the literature would indicate.

I was extremely interested in Doctor Blakemore's paper, because my father reported before this Association many years ago (1911*) twenty personal cases of wiring of aneurysms up until 1910. He did not have the technical refinements Doctor Blakemore had, nor did he obtain very remarkable results other than some alleviation of pain in these cases, but the methods used were rather comparable, including the passage of an electric current through the wire after its insertion in the aneurysm.

DR JAMES C OWINGS, Baltimore. I would like to congratulate Doctor Blakemore on the development of the method he used and the excellent results he has had in his series of cases. About 1940 Doctor Blalock suggested that I go to New York and observe his work. He was extremely kind to me, and I learned his technique in detail. I stayed several days and came home with the idea of trying the same method at Hopkins. Our problem was to develop a means of heating the wire, that took us about two years. We now have an apparatus that can be carried to any hospital or operating room and plugged into any outlet. We have treated seven cases, with not as good results as his, principally because the aneurysms have been very large and five were of the abdominal aorta. I wish to report these cases later in detail, with a description of the new apparatus, so that it will be available to anyone in the country. It is the only one available now and would have to be made by hand. By this time next year I believe I will have enough details so that anyone could have a technician build one. The patient's

* Trans South Surg Assn Vol XXIV, 246 (1911)

pain is relieved in a most striking way. When he is admitted to the hospital he often cannot lie down, cannot sleep, and within an hour after the operation he is relatively comfortable. If nothing more were accomplished, that would be worth while.

I want to thank Doctor Blakemore for his interest and courtesy in helping me get started.

DR DERYL HART, Durham, N. C. A recent patient, having a traumatic aneurysm with a symptom which I had not seen before, seems worth presenting. She gave a history of having a gallbladder operation, following which her physician told her he had had to take deep sutures into the liver to control bleeding. After the operation, for a period of eight months she had occasional bleeding and drained bile from the sinus tract. Also, she had a few profuse hemorrhages from the gastro-intestinal tract, with which she went into collapse and subsequently passed tarry stools. She was studied carefully for the cause of the gastro-intestinal tract bleeding, but nothing could be found either by general examination or by x-ray studies. Because of the persistent sinus, severe pain, and the history of gastro-intestinal hemorrhage, the abdomen was explored.

The adhesions were quite dense over the bed of the gallbladder and, when these were released, there was a gush of blood and the blood pressure dropped precipitously until it was imperceptible. Large quantities of blood were given, while bleeding was partly controlled by packs while the structures were freed from the liver. We found a large laminated clot and the blood was coming through the slit between this and the surrounding structures. The clot was quickly evacuated, the blood was coming from a hole in the liver near the entrance of the hepatic duct. This hole was the size of the end of the index finger, which was inserted as a plug to control the bleeding. The cavity was palpated and was about the size of a golf ball. Even the briefest removal of the finger was followed by a gush of blood and an immediate drop in blood pressure, so that further examination was impossible. The cavity was filled with muscle as the only feasible procedure and sutures were placed through the neck of the opening to hold the muscle in place. It should be noted that compression of the portal vein and hepatic artery did not affect the bleeding.

After a week of uneventful convalescence the patient demanded her release and returned home, over the protest of the hospital personnel and her family. The dangers of further hemorrhage were explained to the patient and to her family. About two weeks later the pain recurred, she was admitted to the hospital, there was a gradual drop of blood pressure and, after about 24 hours, she died as a result of local hemorrhage.

During the past year we have had a somewhat similar case. This patient, a young man who was injured in an automobile accident, was sent in by his local surgeon because of recurring intrainestinal hemorrhages. He had had a number of attacks, each beginning with severe pain in the right flank and followed after about 15 minutes by severe drop in blood pressure and evidence of shock. Each attack was treated by blood transfusions, with relief of shock, and was followed by the passage of voluminous tarry stools. In our hospital he had recurring similar attacks, not influenced by an abdominal exploration, which was negative except for some adhesions at the site of an injury to the liver. We did not feel that a patient could bleed through the common bile duct for so long a time following an injury of the liver. However, this seemed the most likely explanation of the hemorrhages, so a second operation was performed shortly after a hemorrhage had occurred, so as to investigate the possibility of the blood passing from the liver to the intestine through the bile ducts. The common duct and the gallbladder were filled with blood, and the duct was drained in the hope of relieving the pressure and allowing the cavity in the liver to collapse. Recovery was uninterrupted, and the patient has had no further hemorrhages.

DR JOSEPH E. J. KING, New York. I want to report briefly three cases of aneurysm of the abdominal aorta. The first was in a patient 63 years old with a large aneurysm below the renals. It bulged more to the left than to the right. I discussed his case over

the telephone with Dr John Morton and Dr Mims Gage and asked their advice. It was decided that a bilateral lumbar sympathectomy should be done followed by partial occlusion of the aorta above the aneurysm. The sympathectomy was performed at Lenox Hill Hospital on December 13, 1946. The aneurysm reduced to about half the original size. It was much firmer, and the excursions of the pulsation were not so great. Complete ligation of the aorta was not considered. However, on January 6, 1947, Dr Gerald Pratt and I partly occluded the aorta just above the aneurysm and below the duodenum with two umbilical tapes tied over a double thickness cuff of fascia lata about 15 inches wide. The tapes were placed about five-eighths inch apart over the cuff. It was assumed that the occlusion amounted to about one-third or one-half of the lumen. Each tape was tied with three knots. The patient made an uneventful recovery. The aneurysm was somewhat reduced in size, and the patient returned to his business.

Early in March—two months after the operation—I saw him in my office and he was feeling quite well. The pain in his left side and down his left leg had disappeared. Five days later he returned to the hospital after having vomited and passed considerable blood. He was cold and clammy and in shock. Gradually he improved, and repeated small transfusions were given. He had recurring bouts of rather massive hemorrhage per rectum, each episode seemingly a little worse than the preceding. After the fifth he failed to rally, and died on April 21, 1947.

At autopsy it was found that the ligature had cut into the aorta on the anterior side and a knot had pressed through and perforated the overlying duodenum. The condition found readily explained the cause of the vomiting and passing of blood. There was no damage to the posterior wall of the aorta. (Three slides were presented showing the openings in the aorta and duodenum, and the sausage-like mold of the blood clot in the small intestine.)

About six weeks after this patient was operated upon, Dr DeWitt Stetten had a case that was practically identical, on which he carried out the same procedure. The result in this case was the same, death being caused by perforation of both aorta and duodenum with similar signs and symptoms. (Three lantern slides were presented, these were practically duplicates of those in the first case.)

The third case was a 73-year-old gentleman, father of one of my colleagues. The aneurysm was enormous, situated above and at the bifurcation and extending downward into each common iliac artery. We contented ourselves with bilateral lumbar sympathectomy which reduced the aneurysm to almost one-half its size. The patient is up and about in the hospital, and no attempt at partial occlusion is contemplated in view of the previous experiences. Perhaps Doctor Blakemore will see this patient and advise us regarding wiring the aneurysm.

Partial occlusion of the aorta above the aneurysm by means of tape with large knots certainly is to be condemned. It is possible that partial occlusion by means of a wide, rustless steel band overlying three or more thicknesses of fascia lata might be of value, for the reason that autopsy showed marked clotting and obliteration of the aneurysmal sacs following the partial occlusion, and had the knots and thin tape not perforated the aorta and duodenum good results probably would have ensued.

I want to thank Doctors Elkin, Donald and Blakemore for their splendid papers.

DR ARTHUR H. BLAKEMORE, New York (closing). I want to thank Doctor Whipple for his remarks and am particularly glad of this opportunity to express my appreciation of his good counsel and encouragement during the developmental stage of this work.

Doctor Finney's remarks recall the pleasant occasion of my last meeting with his father, when he expressed great interest in our new method of wiring aneurysms.

The deaths reported by Doctors Parker and King confirm what long experience has taught, namely, the dangers of applying encircling, *constrictive* devices (bands, ligatures, etc.) about the aorta. And this is true irrespective of the material employed,

because the constricting pressure alone stops circulation through the vaso-vasorum, which in turn results in ischemic necrosis of the aorta wall

Some years ago the late Dr. Mont R. Reid devised an experimental method of occluding the dog's aorta which embraced the principle of endoarterial occlusion. He introduced a ball of fascia lata through a small longitudinal incision in the aorta and retained the ball in place by two through-and-through mattress sutures. Retaining the principle of endoarterial occlusion, we have devised a method that has proven clinically satisfactory for the progressive closure of the aorta without damage to the vaso-vasorum or the aorta wall. Our method is employed in conjunction with wiring and electrothermic coagulation and is ideally suited to the treatment of arteriosclerotic aneurysm of the abdominal aorta because of its atraumatic features.

In applying our method of progressive endoarterial occlusion with electrothermic coagulation for the treatment of arteriosclerotic aneurysm of the abdominal aorta our present policy is to do first a sympathectomy on the right side. After an interval of ten or more days, a sympathectomy is performed on the left and, through the same incision, the abdominal aorta and the upper part of the aneurysm are exposed.

Since the arteriosclerotic aneurysm almost invariably arises from the abdominal aorta three or more centimeters distal to the origin of the renal arteries, it is feasible to place the obstruction in the aorta immediately proximal to the aneurysm.

Accordingly, a special needle is introduced into the aorta at a point three or more centimeters proximal to the aneurysm and directed obliquely distalward. Fine (No. 34 Ga. B&S), coin silver wire coated with polyethylene containing an irritating plasticiser is passed through the needle into the aorta. Compression of the aorta at the aneurysm junction during the passage of the wire confines it to the aorta and forces the formation of a self-retaining ball of wire immediately proximal to the aneurysm.

As more and more wire is concentrated in the ball, the physical state of turbulence is engendered in the on-rushing blood. The effect of turbulence of the blood, with its hundreds of colliding streams, is to iron out the systolic thrust (pulse wave) before it reaches the aneurysm proper. This effect largely eliminates the "see-saw" pulse strain upon the sac wall of the aneurysm—this is quite a factor in the average arteriosclerotic who, in the absence of elastic recoil in the artery walls, carries oscillometric readings two, three, or more times normal values.

During the passage of the wire for its impedance effect, an oscillometer placed upon the leg satisfactorily registers the decline in pulse pressure—a 50 per cent reduction is the desired amount. After a sufficient amount of wire is passed, the ends of the wire are pushed through the needle with a stylet.

Finally the needle is advanced distalward in the aorta through the ball of concentrated wire well into the aneurysm. At this level two or more 10-meter segments of insulated wire are well distributed within the aneurysm proper. Each segment of wire is heated to 80° C. for a 10-second period. The heat causes a protein coagulum to form upon the wire which, in turn, stimulates blood clotting within the aneurysm. Also, raising the temperature of the wire to 80° C. by passing a direct current through the wire, causes subsequently a heat inflammation in the sac wall of the aneurysm. This helps to promote organization of the blood clot and thus strengthen the aneurysm against sudden rupture or subsequent growth. After heating the respective segments of wire, the ends of the wire are pushed through the needle into the aneurysm and the special needle is withdrawn.

Finally, a film of polyethylene containing an irritating plasticiser is placed about the aorta overlying the exact site of the ball of wire within the aorta. The surrounding tissues are protected from the irritating effects of the above film by covering it with a film of pure polyethylene, which is not irritating to tissues. The plastic film is placed loosely about the aorta so as not to cause pressure necrosis of the wall but to stimulate fibroplasia about the wall of the aorta. Immediately within, the aorta wall is in contact with plastic coated wire which causes a similar reaction. Thus, gradually, over a period

of weeks, the process of fibrotic constriction of the aorta takes place at the site of election immediately proximal to the aneurysm at no time offering the threat of sudden hemorrhage from pressure necrosis of the aorta wall

The above described procedures may be carried out without the necessity of ever really touching or disturbing the aneurysm. This is an important consideration when dealing with arteriosclerotic aneurysms which are prone to develop weakened areas of anemic necrosis of the sac wall. It is this characteristic pathologic feature, in combination with the abnormally high pulse pressure of the arteriosclerotic, that makes this type of aneurysm far more liable to sudden rupture than the syphilitic variety of aneurysm.

To summarize. The combined operation effects a lessening of strain upon the aneurysm by (1) lowering systemic blood pressure (sympathectomy), (2) elimination of the abnormal pulse pressure through the creation of turbulence by the introduction of a ball of wire into the aorta immediately proximal to the aneurysm, (3) reduction of the surface area of the aneurysm by clotting. The aneurysm is strengthened by the promotion of fibroplasia, clot organization, the result of heat inflammation. Finally, the induction of chemical inflammation through the employment of polyethylene containing an irritating plasticiser in contact with the aorta wall immediately proximal to the aneurysm, sets the stage for progressive endoarterial occlusion.

When dealing with large, rapidly growing arteriosclerotic aneurysms of the abdominal aorta, it may be wise, after a three to six months interval, to do a second stage procedure. At this operation an aneurysm which has become well supported by clot from a previous procedure may be safely approached transperitoneally through a left rectus incision. At the second stage, as indicated, the following may be accomplished: (1) Introduction of additional plastic (polyethylene) coated wire into the aorta immediately proximal to the aneurysm for its impedence effect, (2) Introduction of additional segments of insulated wire into the aneurysm for heating, in areas where more clot is desirable, (3) In those cases having considerable clot within the aneurysm it is safe to reflect the peritoneum lateralward and apply polyethylene film containing an irritating plasticiser about the anterior and lateral portions of the aneurysm. This film is, of course, overlaid with a non-irritating film of pure polyethylene to protect the overlying peritoneum.

Doctor Owens, with the aid of his talented engineer brother-in-law, has constructed a compact heating unit that is satisfactory for the electrothermic method, if due caution is taken against overheating the wire. Doctor Owens is a most careful operator, and I shall expect of him excellent results. Though our equipment is more cumbersome, the ratimeter employed by us does indicate the exact temperature of the wire at all times during the heating period.

ENDOMETRIOSIS*

JOE V MEIGS, M D

BOSTON, MASS

PERHAPS IT IS UNNECESSARY to write again upon the subject of endometriosis. However, after many years of careful observation of this phenomenon certain definite ideas have arisen as to its cause, its treatment, and its significance. The conclusions drawn by one interested in the subject for 26 years may be of help in solving a surgeon's reaction to the treatment of some of the problems presented. There can be no doubt about the great frequency of endometriosis. So many of these endometrial lesions are found in patients who have no symptoms attributable to their endometriosis, that it is logical to feel that most endometriosis simply represents abnormal physiology and not true disease. It is possible that it has even increased in frequency but the apparent increase may be due to the more careful observation of and to more careful selection of tissue for the pathologist. To me it seems to be much more evident than ever before. In 1922, one year after the time of John A. Sampson's epoch-making studies of the disease, I was assistant to the late Dr. William P. Graves at the Free Hospital for Women in Brookline, Massachusetts. Dr. Graves was extremely interested in the problem presented by Dr. Sampson and a careful search for endometrial lesions brought very few results. Later, as assistant to the late Dr. George W. W. Brewster, we were still unable to find frequent endometriosis. Within the last ten years the author has found that a very large percentage of his gynecologic cases operated upon for various reasons have the tell-tale small, blue to black, puckered areas and that after excision of such areas and microscopic study by the pathologist a diagnosis of endometriosis could be made. It is possible that better exposure of the deep pelvis because of the routine introduction of total hysterectomy allowed areas in the region of the utero-sacral regions to be more carefully observed. It is probable that the routine excision of these small suggestive spots and the fixing of them in small bottles for the pathologist has raised the number of correct diagnoses. At the present time it is rare that the suspicion of endometriosis of a given area is not confirmed in the laboratory. If the small, puckered areas are not removed and fixed separately, it is most difficult for the pathologist to find the areas when the removed uterus arrives in the pathologic laboratory. The excised uterus, shaggy and covered with blood, hides the tiny, dark, pigmented areas nearly completely.

FREQUENCY

In the second private series (Table I) reported in this discussion 35 per cent of the cases operated upon abdominally for varied gynecologic complaints, have endometriosis. The second series reported from the Massachusetts General Hospital (Table I) shows an 8.25 per cent involvement. This discrepancy

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Tuesday, December 9, 1947.

TABLE I

	Consecutive Cases	Endometriosis Microscopically	Endometriosis Grossly	Endometriosis Microscopically or Grossly
Private—I	400	112-28%	32-8%	144-36%
Private—II	400	122-30.5%	18-4.5%	140-35%
M G H—I	400	21-5%	11-3%	32-8%
M G H—II	400	23-5.75%	10-2.5%	33-8.25%

may be due to the fact that our Resident Surgeons and Assistant Resident Surgeons, who do a considerable amount of the surgery, are not sufficiently interested in or acquainted with the disease. However, during the period of the second series most of the young surgeons have been assistants on my private service and have done their own surgery in the newly established Vincent Memorial Hospital Gynecologic Service in our hospital. With the House Staff's careful gynecologic supervision and after frequent discussions of this problem, the percentage of endometriosis in the ward group has not increased. I do not believe that this is due to lack of careful observation or lack of interest, but rather to a difference in attitude toward child bearing among private patients and ward patients. Private patients marry and have children later than those in the wards of the hospital. This difference will be further discussed under the heading of *etiology* below. The areas involved by endometriosis (Table VIII), and this paper is not concerned with adenomyosis of the uterine wall, are many. The ovary, the tube, the peritoneum covering the uterus, the anterior bladder flap, the uterosacral ligaments, the round ligaments, the umbilicus, the rectovaginal septum, the sigmoid, the small intestine, the appendix, as well as other areas have been found to be involved. It is interesting to note that practically all of the lesions are within the pelvis, thus proving a relation to the pelvic celom.

ETIOLOGY

Endometriosis may have various causes and it may be impossible accurately to determine its etiology. Several outstanding theories have been presented. Cullen showed that adenomyosis is due to a down growth of the endometrium into the uterine musculature. In 1897 he reported his first case of adenomyoma of the uterus.⁶ His work has never been refuted and his view is accepted as explanation for this type of aberrant endometrium. Adenomyoma, although aberrant endometrium, is not what we are discussing today. In 1897 Pfannenstiel²⁴ reported a case of endometriosis of the rectovaginal septum and in 1899 Russell,²⁵ of the Johns Hopkins Hospital, reported the finding of endometrial tissue in the ovary. In 1909 Meyer reported a case of endometriosis of the bowel.²⁰ In 1921 came the first enlightened explanation for aberrant endometrium, in a painstaking study by Dr. John A. Sampson of Albany.^{26, 28, 29, 30, 31} His numerous ideas include, first of all, his famous tubal reflux theory and the suggestion that tubal epithelium may become acti-

vated as endometrial tissue does and produce menstruating lesions. He also suggests the possibility of lymphatic drainage as responsible for extension of the disease. His suggestion that cast-off endometrium at menstruation may flow through the tubes, adhere to and grow in the ovary or in the pelvis, is a highly provoking thought and may be responsible for some endometrial lesions. Endometriosis as a rule occurs after the age of 26 (Table II), thus giving plenty of time for many menstrual refluxes to occur. Interestingly enough, the fimbriated ends of the tubes are nearly always open in endometrial lesions. Only very occasionally have we found the tubes closed and it is possible that the endometria started to grow before the tubes were closed. Blood has often been seen flowing from the tubal ostium, and photomicrographs have demonstrated endometrium in the tubal lumen. It is difficult, however, to believe that cast-off endometrium is living and can be implanted on other tissues as in a skin graft. Experimental work along this line has not been conclusive enough to support his idea of the growth of cast off endometrium. Bartelmez¹ states that microscopic inspection of cut sections of the uterus in its entirety during menstruation shows viable endometrium in the uterine canal. Markee's work¹⁷ in experimental transplantation of endometrium into the eye of the monkey is definitely against the reflux theory. He has been able to transplant endometrium into the eye easily yet he has never in many experiments, seen a piece of cast-off menstruating endometrial tissue in the eye attach itself into the chamber of the eye and grow. Sampson's reflux theory is probably not the most significant etiologic factor in most cases of endometriosis. Von Recklinghausen's theory that endometriosis arises in the left-over pieces of the Wolffian ducts has been discarded. Halban⁹ has suggested that normal endometrium can metastasize through the lymphatics. This theory may account for the lesions found in the lymph nodes of the pelvis and in the groin.²⁷ One definite case of endometriosis reported in the pleura⁴ supports his theory. Halban's theory is a good one and yet it is doubtful that it can explain the nodules so frequently encountered in the pelvis and in the pelvic organs. Iwanoff of Russia^{12, 13} and Meyer²¹ of Germany independently believe that endometriosis is due to the stimulation of growth of embryonal cells of the celomic epithelium. The celomic epithelium is also responsible for the epithelium of the upper vagina, the endocervix, the endosalpinx, and the covering of the ovary. Iwanoff and Meyer postulate that under certain conditions, such as inflammation or injury or irritation due to menstrual blood, that embryonic cells of the celom may grow and produce Muellerian and hence endometrial tissue. This theory, or the interpretation of this theory, seems to be a satisfactory explanation of endometriosis. It even accounts for the finding of endometrium in the forearm²³ in one case and in the thigh in two cases^{16, 32}. The arm and leg buds in the embryo contain celomic epithelium and left over cells from these buds may grow and produce endometrium. In our observations of endometriosis, under-development of the pelvic organs is frequently present. Under-development of pelvic organs suggests the presence

TABLE II—Ages

	Endometriosis				No Endometriosis			
	Private		M G H		Private		M G H	
	Series I	Series II	Series I	Series II	Series I	Series II	Series I	Series II
10-19				3 03%	2 38%	1 9%	6 2%	1 %
20-29	4 3%	8 6%	18 8%	3 03%	8 09%	9 2%	23 8%	15 5%
30-39	34 3%	25%	21 9%	42 42%	26 66%	31 6%	28 7%	33%
40-49	51%	55 7%	31 25%	36 36%	43 33%	50%	28 4%	39%
50-59	9 5%	10%	25%	15 15%	11 9%	7 3%	8 7%	8 1%
60-69	93	7%	3 1%		5 7%	4 68%	3 3%	3 %
70 plus					1 9%		8 %	

TABLE III—Symptoms

	Private		M G H	
	Series I	Series II	Series I	Series II
	144	140	32	33
Pain not dysmenorrhea	32 6%	26 4%	43 7%	48 48%
Acquired dysmenorrhea	12 5%	26 4%	9 3%	30 3%
Infertility	32 9%	36 1%	7%	

of inactive, embryologic, left-over cells which would increase the percentage of endometriosis. Patients with dysmenorrhea, for instance, frequently have endometriosis and many patients with dysmenorrhea have small and underdeveloped organs. Those patients with the so-called "congenital erosion" of the cervix frequently have endometriosis. Thus it would appear that the celomic epithelium rest theory has a good deal in its favor. Upon Iwanoff's and Meyer's conception rests our theory and understanding of endometriosis. It is our opinion that endometriosis occurs because of a lack of early and lack of frequent child-bearing (Table V). How does this affect the problem? In nature certainly early child-bearing and frequent child-bearing is the usual thing. This may be prevented by untoward circumstances, such as caging and domestication. Certainly some monkeys who menstruate, as women do, mate early following the menarche and have offspring, nurse, and then become pregnant again. In their natural habitat they probably follow this sequence until they either physiologically can have no more offspring or die. This is what nature expects of animals. The human being does not carry out nature's rules. Our grandmothers and great grandmothers probably more nearly approximated the ways of nature than the modern women, at least up to World War II. For a number of years, due to economic conditions, young people have not been able to marry early and if married, found it necessary to prevent pregnancy. This allowed many menstrual cycles to occur (Table VI) and the varied hormonal reactions of menstruation probably stimulated the celomic cells to grow and produce Muellerian growth. Certainly menstruation is not supposed to occur monthly for years without interruption. Menstruation is an indicator to the young woman that she is not pregnant. It is unlikely that women with ten or more children menstruate frequently. Late and infrequent childbearing is not normal physiologically. It is likely,

therefore, that this abnormal physiology may have some definite effect upon the pelvic celomic tissues. It will be noted in this study (Table V) that most patients with endometriosis have none, or one, or two children, and the greatest number falls into the group who are denying their normal functions. Dr. Thomas R. Goethals⁸ demonstrated that the primipara of his private practice fall into two groups: 25 years old and under, and 26 years and over. Seventy per cent of 200 patients were in the older group and became pregnant for the first time at or after the age of 26. This group then, assuming that they had the menarche at 14, menstruated for 12 or more years without interruption. This is certainly not normal and if the celomic epithelium contains cells capable of

TABLE IV

	Private		M G H	
	Endometriosis	No Endometriosis	Endometriosis	No Endometriosis
Series I	144	256	32	368
Single	41-28 5%	56-21 9%	4-12 5%	62-17%
Married	103-71 5%	200-78 1%	28-87 5%	306-83%
Series II	140	260	33	367
Single	33-23 6%	41-15 9%	5-15 1%	52-14 16%
Married	107-76 4%	219-84 2%	28-84 8%	315-85 83%

TABLE V

	Endometriosis		No Endometriosis	
	Private	M G H	Private	M G H
Fertility of married group				
Series I	66 9	93%	83 1%	88 5%
Series II	63 8%	100%	77%	85 4%
Two children or less				
Series I	73 6%	43 4%	53 2%	50 3%
Series II	79 1%	67 8%	57 39%	38 7%
Age at marriage 25 or over				
Series I	53 7%	16%	37 6%	17 9%
Series II	57%	11%	37%	21%
Age at first child 25 or over				
Series I	60%	23 5%		..
Series II	69 8%	14%	55 4%	30 9%

producing endometrial epithelium, it had plenty of time to do so. Dr. John Fallon of Worcester, Massachusetts⁷ recently stated that a woman should have a child at least every five years to prevent the onset of endometriosis. It has always seemed to me, believing in this theory since it was suggested in an editorial in *Surgery, Gynecology and Obstetrics* in 1938,¹⁸ that if women had their children when they were young, its subsequent development after they had had their children, would not be of too great importance. It is suggested that the celomic epithelium theory of Iwanoff and Meyer is correct and that the growth of endometrial cells is due to an abnormal physiology and

that this abnormal physiology is late and infrequent childbearing. This well considered etiologic factor is introduced as an addition to the many suggested reasons for the frequency of endometriosis.

SYMPTOMS

The symptoms of endometriosis are well known and do not need elaboration. Dysmenorrhea especially of an acquired type, pelvic pain, infertility, and abnormal menstruation in the form of too much bleeding are the usual symptoms (Table III). Pain in the groin or umbilicus due to an endometrioma in that region is rare but understandable. Periodic attacks of intestinal obstruction at the time of the menses sometimes occur. Cyclic bleeding from the rectum was formerly thought to clinch the diagnosis of endometriosis of the bowel, but it is obvious from a study of the roentgen-ray findings in these cases and of the tumor after resection, that there is no break in the continuity of the bowel mucosa over the lesion and, therefore, bleeding should *not* take place. Fallon has demonstrated that endometriosis can occur in a much earlier age group than has usually been considered. Surgeons who operate upon young girls for pelvic pain, and who have been forced to consider the diagnosis of chronic appendicitis, should carefully inspect the pelvis. According to him, endometriosis may be found to be the cause of the symptoms.

DIAGNOSIS

The diagnosis of endometriosis may be suggested by the symptoms and, if in addition to the symptoms typical physical evidence is found, the diagnosis should be easy. The easiest clue to the diagnosis on physical examination is a rough, firm, and "shotty" feeling behind the cervix which is best felt by rectal examination. The "shotty" nodules in the uterosacral ligaments can be easily felt and in my experience this is the earliest and most frequent physical finding in this disease. If the lesion is more widespread and if the ovaries are involved and adherent, the vaults give the same shotty feeling and occasionally a cyst with a soft spot, the area of its adherence to the broad ligament, may be felt. Proctoscopy with the expectation of viewing an endometrioma of the bowel is not successful. The involvement of the bladder, however, can be easily observed by cystoscopy. If a firm nodule is felt behind the cervix on the vaginal side, inspection of this area may easily show a group of small, black to blue nodules and clinch the diagnosis of endometrioma of the recto-vaginal septum.

To make the definite and microscopic diagnosis of endometriosis let me stress the importance of the surgeon, at the time of operation, excising the small, suspected areas and placing them in a fixative for examination in the laboratory.

TREATMENT

The treatment of endometriosis is clear-cut (Table X). Inasmuch as an endometrioma as well as the endometrium is under the control of the ovarian hormones, castration will always check the progress of the lesion. This is a

satisfactory and correct treatment in the older age group, especially if the endometriosis is so extensive that it may injure another organ, for example the bladder, the bowel, or the ureter. However, in a girl who has had no children and wishes them, such radical treatment as castration is to be deplored. In these days of accurate, careful, safe surgery it is far better to resect the bladder or intestine, to resect or transplant the ureter, than to castrate a girl who wishes children and who is at the age where her sexual relations may mean her happiness.

Endometriosis is a slowly growing process, and it may take years for it to advance to a large size. It is rare to see a chocolate cyst greater than a small orange. Endometriomas of the peritoneum, usually very small, rarely are larger than 1 centimeter. They may become widespread and may pucker up

TABLE VI

	Private		M G H	
	Endometriosis	No Endometriosis	Endometriosis	No Endometriosis
Marriage to first pregnancy				
2 years or more				
Series I	62.2%	53%	54.0%	41.1%
Series II	66.1%	55%	67%	40%
Menarche to first pregnancy				
10 years or more				
Series I	55.5%	67.3%	38.4%	35.9%
Series II	79%	72%	31.6%	39.8%
Menarche to endometriosis				
17 years or more				
Series I	93.3%		75%	
Series II	89.4%		96.3%	

the peritoneum but they never become large enough to endanger the patient's life. As a matter of fact, it is probable that many of these lesions are in an end stage when seen. Most endometriomas are surrounded by scar tissue, as shown by Sturgis,³³ and pain is caused by slight activity and swelling in a small number of endometrial glands that may be active. Most endometriomas contain inactive endometrium and do not enlarge. It has been my privilege recently to reoperate upon a patient who had endometriosis in the uterosacral ligament seven years before. Sufficient tissue, but not all, was removed to make the diagnosis at that time and yet at this examination the endometriosis left behind had not changed in the seven years. If many of these small lesions are inactive, it is wrong to castrate patients for endometriosis. The operation for endometriosis should be done for pain, not simply because endometriosis is found. Most large chocolate cysts are probably not active or, if so, are active in only a few places, for microscopic examination, according to Sturgis, shows that the epithelium is cuboidal and no longer cylindrical. These lesions did menstruate but the menstrual fluid under pressure has flattened the epithelium, and activity has ceased. Surgery is correct if an ovarian lesion is suspected.

and endometriosis cannot be accurately diagnosed, for it is far wiser to operate and find a small cyst than to let a cancer of the ovary grow. If a woman is young and wants children, the treatment for the chocolate cyst is excision of the cyst from the ovary. This is very easy to do, and the cyst wall will shell out just like a follicle cyst, and the ovaries can be easily reconstructed. In endometriosis the posterior cul-de-sac is often pulled up on to the back of the uterus. This fact should be recognized and after the cul-de-sac is released a proper uterine suspension should be done to keep the pelvic organs away from the raw areas in the deep pelvis. This adherence of the cul-de-sac with its obliteration of the uterosacral ligaments should be well considered before total removal of the uterus is contemplated, for the rectum can be easily entered here. This adherent tissue is characteristic of endometriosis. The cul-de-sac can best be released if the uterus is pulled up tight with a double hook—the area of adherent growth frequently splits, and the cul-de-sac will begin to separate, if it does not, by placing the edge of a knife against the adhesive area it will start the split and the cul-de-sac can quickly be freed from the uterosacral ligaments and back of the cervix and posterior wall of the vagina.

In women with ovarian endometriosis, when it seems wise to spare ovarian function, it is perfectly satisfactory to remove the uterus and cervix and the larger ovary with its cyst but to resect the cyst from the other ovary and leave it behind with its tube. Inasmuch as the disease progresses slowly, if symptoms should recur, roentgen-ray treatment will stop ovarian function and thus cause a cessation of the growth of the endometriosis. In nearly all instances conservative surgery with preservation of ovarian function should be the guide to treatment, and castration should be reserved for those lesions that are too difficult to solve by conservative surgery. We have had the opportunity to observe two cases of endometriosis of the rectovaginal septum following castration, and it was three years before the lesions finally became white and disappeared, leaving only a very slight puckering in their place. Slow growth and slow disappearance seems to be the rule.

In bowel endometriosis, if the lesion is found accidentally and the patient has no intestinal symptoms, castration is best in the older age group and resection of bowel for the young woman, and especially for the young woman who wishes children and is in the child bearing age. A good test to determine the result of treatment, if bowel symptoms only are present at the time of operation, is the use of an estrogen to prevent ovulation. If the distention of bowel or if pain in the pelvis is rhythmic and accompanies a normal period it is possible by preventing ovulation with estrogen to produce an abnormal period and thus prevent the occurrence of symptoms. Relief of symptoms demonstrates that it is wise to castrate the patient and to expect relief of distention and pain. This test is very satisfactory in determining whether or not a patient's pain is made worse by the menstrual cycle, for by preventing ovulation a normal secretory endometrium and normal cycle is avoided. If

pain is prevented, then the cycle is responsible, but, if there is pain at the time of withdrawal bleeding, it is not connected with the menstrual cycle

It has been suggested by Hirst of Philadelphia,¹⁰ and Miller of Hartford,²² that testosterone is a satisfactory treatment for endometriosis. Amenorrhea may be caused by this treatment for 2-3 months. It is said that the lesion softens and in some patients who were sterile, fertility followed, and in some cases operation was made easier. Kanarky from Houston, Texas,¹⁵ advocates large doses of stilbestrol for the same purpose. It is very difficult to see how

TABLE VII —*Region of Endometriosis*

	Private		M G H	
	Series I 144	Series II 140	Series I 32	Series II 33
Ovary	86-59 7%	74-52 8%	11-34 4%	21-63 8%
Uterosacral ligament	31-21 5%	59-42 1%	3-9 3%	2-6 06%
Peritoneum	8-5 6%	13-9 2%	1-3 1%	2-6 06%
Bowel	9-6 25%	6-4 3%	2-6 25%	2-6 06%

TABLE VIII —*Regions of Endometriosis*

	Private		M G H	
	Series I 144	Series II 140	Series I 32	Series II 33
Ovary	86-59 7%	74-52 8%	11-34 4%	21-63 8%
Uterine surface	64-44 4%	34-24 2%	21-65 6%	8-24 2%
Cervix		2-1 4%	1-3 1%	1-3 03%
Uterosacral ligament	31-21 5%	59-42 1%	3-9 3%	2-6 06%
Peritoneum	8-5 6%	13-9 2%	1-3 1%	2-6 06%
Tubes	12-8 3%	9-6 4%	1-3 1%	3-9 09%
Cul de sac	5-3 5%	7-5%	3-9 3%	6-18 1%
Appendix	1- 7%	3-2 1%	1-3 1%	1-3 03%
Bowel	9-6 25%	6-4 3%	2-6 25%	2-6 06%
Round ligament	4-2 8%	1- 7%		
Lymph nodes in iliac area		1- 7%		
Umbilicus			1-3 1%	
Rectovaginal septum	2-1 4%		1-3 1%	
Vagina			1-3 1%	

the use of any hormone can influence a lesion that is in an end phase and a lesion that takes three years to vanish, nevertheless, for the purpose of discussion, this newer method of treatment should be mentioned

In the treatment of the dysmenorrhea of endometriosis it has often been suggested that a presacral neurectomy be done, and in those patients who have central pain and not lateral pain a presacral neurectomy is satisfactory if conservative surgery is contemplated. It is best to do the neurectomy before the endometriosis is disturbed, to prevent spilling endometrium into the retroperitoneal wound. Dr Willard Cooke of Galveston⁴ advocates cutting the infundibular pelvic ligament to enervate the ovary in lateral pain but inasmuch as this destroys two thirds of the ovarian blood supply, it cannot be advised

RESULTS OF TREATMENT

The results of conservative treatment are very satisfactory, and it is rare that an operation has to be repeated. This suggests that in most instances the lesion is very slow to progress. Re-operation has been reported as necessary in from 9-29 per cent in various clinics. In our clinic with conservative methods, it is indeed rare. In from 9-29 per cent of reported cases a preg-

TABLE IX

	Private 144	M G H 33
Type of endometrium		
Secretory	46-32.8%	9-27.27%
Early secretory	5-3.6%	1-3.03%
Late secretory	1- .7%	1-3.03%
Proliferative	47-35.5%	8-24.24%
Early proliferative	1- .7%	
Late proliferative	2-1.4%	
Senile cystic	1- .7%	
Inactive	5-3.6%	1-3.03%
Atrophic	2-1.4%	1-3.03%
Negative	5-3.6%	
Menstruating	1- .7%	
? type	24-17.1%	12-36.36%

TABLE X—Surgery

	Private		M G H	
	Series I 144	Series II 140	Series I 32	Series II 33
Endometriosis cases				
Radical (both ovaries removed)	57-39.6%	12-8.6%	17-53.1%	8-24%
Conservative (conservation of ovaries)	87-60.4%	128-91.4%	15-46.9%	25-76%
No endometriosis	256	260	368	367
Radical (both ovaries removed)	72-29%	18-7%	98-26.6%	39-11%
Conservative (conservation of ovaries)	183-71%	242-93%	270-73.4%	328-89%
Conservative for Pregnancy				
Endometriosis cases	144	140	32	33
Conservative	21-14.6%	16-11.42%	4-12.5%	5-15.1%
Pregnancy following	6-28.6%	2-12.5%		
Radical (uterus with or without ovaries)	123-85.4%	124-88.5%	28-87.5%	28-84.8%
No endometriosis	256	260	368	367
Conservative	52-20.3%	38-14.6%	119-32.3%	90-24.5%
Pregnancy following	5-9.6%		3-2.5%	
Radical (uterus with or without ovaries)	204-79.7%	222-85.4%	249-67.7%	277-75.5%

nancy has followed conservative surgery (Table X). This is most satisfactory, and it is possible that this per cent of fertility can be improved. Patients with endometriosis are sterile because the ovary is fixed and the normal interplay of tubal and ovarian movement is prevented. The egg cannot be deposited into the fimbriated end of the tube, as it should be. The tube is fixed in an abnormal position. It is, therefore, important that patients be advised to try to become pregnant very soon after conservative operation. If the tubes and ovaries are free, better results can be expected than if they are firmly adherent.

THE SIGNIFICANCE OF ENDOMETRIOSIS

The significance of this lesion is that it is probably due to lack of early child-bearing and infrequent childbearing. It is due to lack of normal use of the female organs, thus allowing abnormal physiologic processes to persist. There is great need in these times for financial aid to our daughters and sons, and it is my opinion that financial help to our children will reduce the incidence of endometriosis and will also reduce the incidence of unhappy and childless marriages. In the present economy of our country it is nearly impossible for a young man to make enough money to support his wife. Therefore it is up to all as fathers and mothers to permit our children to marry early and to aid them financially until they are able to care for themselves. In some instances this will be impossible for fathers to do. Our children must realize that by being helped when young they need not expect much in the way of an inheritance. Our children will not need help later, for if they are sufficiently able they will be able to support themselves and will not need or expect any money to be left to them. Help when they are young is very important and by supporting their marriages and helping the young wife to have her family we will accomplish much more for the world than we will by trying to save for them when they get older. The idea of better pay for young men should be taken into account in industry, and workers should be paid more earlier in life and not expect great increases in their salaries or earning capacity as they get older. The level of income should be increased for young men with wives. They should be encouraged to keep our country populated by having children when they are young, and not allowing them luxuries when they are older. This philosophy for our children is an extremely important one, and larger pay will not be necessary when they are older. I hope that it may strike a responsive note among the members of this association.

DISCUSSION

Endometriosis is one of the most common and most talked of pathologic lesions, not only in gynecology but in surgery. It is replacing the surgery of the "cyst of the ovary." Cyst surgery is going out of existence in most parts of the country. Surgery for endometriosis should be done only for definite reasons, and significant symptoms are the real guides for such surgery. Just as certain fibroids should not be operated upon, so certain patients with endometriosis need not be operated upon. The excellent prognosis of this condition, the fact that in most cases the activity when recognized is over, means that unless there are definite symptoms such as sterility, severe dysmenorrhea, and intestinal obstruction cases with endometriosis can be watched, just as well as patients with small fibroids.

THE MATERIAL

In this paper, attention is drawn to the comparison between two series of 400 private patients and two series of 400 Massachusetts General Hospital patients.¹⁰ The first series of patients were collected in the years 1936-1941,

TABLE XI — *Last Pregnancy to Endometriosis*

	Private		M G H	
	Series I	Series II	Series I	Series II
Fertile	65	67	26	28
Less than 1 yr			1	
1 yr	1	3		
2 yrs	1	4	2	
3	1	2	2	1
4		3	1	3
5		1	2	
6	2	1	1	3
7	1		2	1
8	4	3	1	
9	1	2		2
10	5	2	3	
11	1	6	1	2
12	5	5		1
13	2	4	2	1
14	2	3	1	2
15	2	4		1
16	4	5		
17	1	3		1
18	6	1		1
19	3		1	1
20	3	1		
21	1	5		
22	2			1
23	1	1		
24	2	2		1
25	1	2		
25 plus	5	1	2	3
?	8	3	4	3

and the second, 1945-1947. It is evident that most patients with endometriosis are from the more well-to-do group. Also it is evident that late childbearing is the choice of private patients as compared to earlier marriage and many children among the ward patients. This investigation was carried out to prove that the first comparison was not a misconception and that the same trend is evident in the latter series as in the early ones. It is possible that there will be a definite difference in the next five to ten years for the war years produced earlier marriages and childbearing. It will be interesting to see if that group of young women who married early and had children are as frequently affected with this usually innocuous but sometimes frightening disease. The tables explain the results and a careful perusal of them indicates that the trends are as they have been presented.

CONCLUSIONS

1 Endometriosis is a common disease and the surgery of endometriosis is supplanting surgery for "cyst of the ovary."

2 Endometriosis is not such a frightening lesion as has previously been considered.

3 The stage in which the disease is seen is often at the end of activity.

4 Endometriosis by interfering with the normal motion of the tubes and ovaries may interfere with fertility and as such should be corrected.

5 Resection of ovarian endometriomata and conservation of ovarian tissue is essential in young women both for childbearing function and for sexual function

6 The theory of the growth of the celomic epithelium due to delay in childbearing is the most important etiologic factor in endometriosis

7 Radical surgery should be rare in endometriosis

8 Endometriosis of the bowel should be treated by resection and not castration in young women

9 The economic condition of the world behooves us as parents to help our children financially to marry early and have children. It is suggested that higher wages be given to young married couples

10 Endometriosis may be aided by treatment with testosterone or by stilboestrol, but this treatment is not permanent

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DISCUSSION —DR WAITER R HOLMES, Atlanta, Ga I have enjoyed hearing Doctor Meigs' paper and the discussion on endometriosis I would like to agree with and emphasize his conservative attitude in regard to the treatment of this disease I am convinced that in the majority of patients on whom a diagnosis of endometriosis is made surgical interference is not necessary Patients having endometriosis deserve a frank discussion of their condition with explanation of the cause of their premenstrual discomfort and other pelvic symptoms Intelligent patients will often prefer to endure their discomfort rather than be subjected to a mutilating pelvic operation In the child-bearing period where operation was necessary, conservative surgery was rewarded by subsequent pregnancies in 12 per cent of my private patients In the more advanced stages of the disease, complicated by fibroids and adenomyosis, hysterectomy with preservation of some ovarian tissue has given uniformly satisfactory end results Although bilateral oophorectomy will cause regressive changes in endometriomas, the cure is often worse than the disease There is no more tragic human figure to haunt our reception rooms than these castrated derelicts of femininity

Doctor Meigs' theory that early marriages and early pregnancies will prevent endometriosis is extremely interesting The parental financial aid suggested by Doctor Meigs, to make it possible for young people to marry early, if carried out, would certainly be a great boon to future sons-in-law and daughters-in-law

DR JOHN C BURCH, Nashville, Tenn Endometriosis is a disease which is not as progressive as formerly thought I agree with Doctor Holmes that observation and conservative treatment are indicated in most instances It is an infiltrative disease with

a very low malignant potential. On account of its infiltrative nature it is almost impossible to remove the process by local excision. Furthermore, progress of the lesion is dependent upon hormonal stimulation by the ovaries. It seems wise, therefore, to approach the case from its physiologic aspect and to ascertain the functional needs of the patient.

Many times it is impossible to dissect the cyst from the ovary and leave any functioning ovarian tissue. Open the cyst and depress it and the ovary in many instances will return to normal function. I had an illuminating experience some years ago. The patient was a woman of 25, engaged to be married, who had an ovarian cyst. At operation a large chocolate cyst was found in the left ovary and one on the right. I felt it would be a terrible thing to make a clean sweep. I simply decompressed both cysts, closed up, and in three months she was married and in 15 months was a mother.

DR. ROGER G. DOUGHTY, Columbia, S. C. I simply want to add my voice to the conservative attitude in the treatment of endometriosis, based originally on an experience I had in 1924. The patient was a young woman with extensive endometriosis. In the course of operation, having been impressed with the necessity of removing the ovaries in such cases, I hesitated, and finally wound up by removing as much as I could of the diseased tissue, but leaving both ovaries. She married about two years later, has had three or four perfectly normal children and has had no difficulty in the pelvis. Following that experience I have been extremely conservative in handling endometrial lesions and, most of the time, do not do even a hysterectomy, let alone an oophorectomy. I have not had cause to regret this attitude through the years.

THE CLINICAL EVALUATION OF CHOLANGIOGRAMS*

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THE POTENTIAL VALUE of cholangiography was emphasized several years ago by Mirizzi¹, Saralequi,² Best and Hicken,³ Walters and Snell,⁴ and many others. Since that time the value of the "delayed" cholangiogram has been established beyond question, and its routine use is general and well known. The "immediate" cholangiogram has had a limited trial and is rarely used, because of technical difficulties and the lack of easy access to adequate Roentgen-ray equipment and personnel. However, the procedure is theoretically sound, and definite progress in the performance and interpretation of "immediate" cholangiograms has been reported by Schuberth and Sjogreen, MacDonald and others.

For the past several years it has been our practice to make routine "delayed" cholangiographic examinations in all cases of common duct drainage or biliary fistula. In practically all cases there has been the satisfaction of having a visual demonstration of the common duct entirely free of stones or other obstruction. On the other hand there has been an occasional case in which the "delayed" cholangiogram demonstrated that a stone had been left behind during the common duct exploration, and a secondary operation was usually necessary for its removal. So we are convinced that digital and instrumental examination of the common bile duct is not always adequate. The various methods of using the probe, the scoop, the forceps, irrigation and suction do not always give positive proof that all stones have been removed. However, "delayed" cholangiographic study does give visual proof of the obstruction or patency of the bile ducts. And if equally as satisfactory cholangiograms could be obtained by the "immediate" method, secondary operations would be obviated and visual knowledge of the condition within the bile ducts would be obtained during the operation. This has been accomplished with a limited degree of success, but the technic of the procedure must be simplified and improved by each part of the team—the Surgeon, the Anesthetist, and the Roentgenologist—if it is to have wide acceptance and application. If given proper equipment one should, theoretically, be able to obtain visual information of the bile ducts comparable to that obtained by the Urologist in examinations of the urinary tract.

In the attainment of this objective, a number of problems and technical details are encountered. One hesitates to bring additional equipment into the operating room and add time and expense to the operation, unless results are definitely improved. In acute or extensive involvement of the gallbladder it may be difficult to inject the opaque medium into the biliary tree. The inability

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Tuesday, December 9, 1947.

ity of the anesthetized patient to cooperate may cause movement on the film. Pressure or tension on the common duct or artefacts within the duct may cause misinterpretation of film.

However, we are convinced that cholangiography has great potential value as an adjunct to present day methods of gallbladder surgery. With

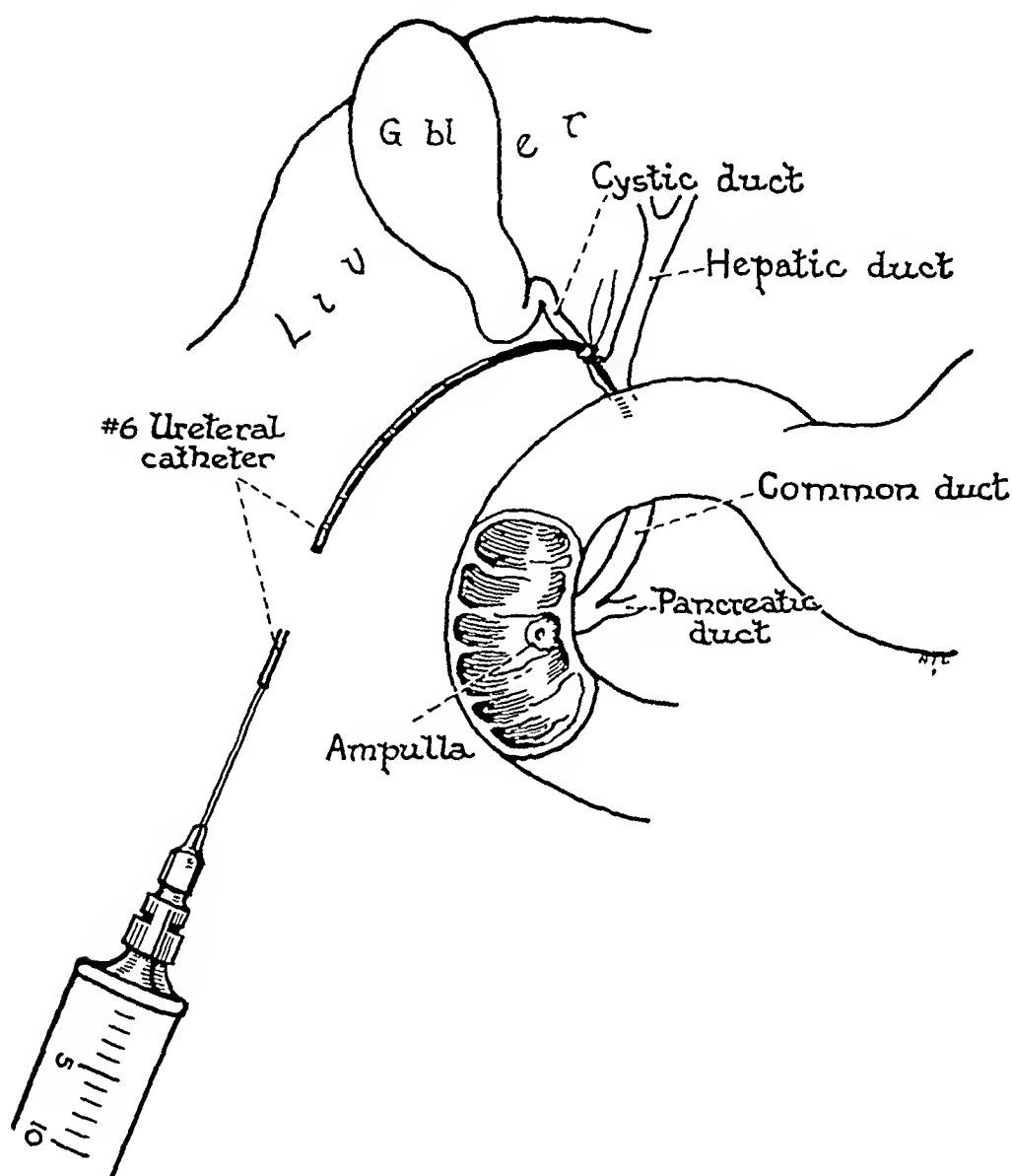


FIG 1 Ureteral catheter passed through small incision in cystic duct for injection of opaque medium

our present technic and the cooperative effort of the Anesthesia and Roentgen-ray Departments, we have been able to obtain "immediate" cholangiograms which have given us assurance of a normal ductal system or positive evidence of pathologic conditions in a high percentage of cases. In the cases in which we have not accomplished this result, it has usually been due to too active respiratory movement in large, thick patients, or to some minor technical error on the part of the surgical team or the roentgen-ray technic. It has

been found to give useful and desirable information in the following type of cases

1 In common duct drainage and biliary fistula, "delayed" cholangiogram is used in all cases to determine the presence of stones or other pathologic conditions, and to observe the return of the common duct to normal size and function

2 In acute cholecystitis, if cholecystectomy is performed, an "immediate" cholangiogram can be obtained by injecting the opaque medium through the cystic duct. If only a cholecystostomy is performed, there is no practicable advantage accomplished by an "immediate" cholangiogram, but a "delayed" cholangiogram, obtained by injecting an opaque medium through the drainage tube after free drainage has been established, will often give invaluable information

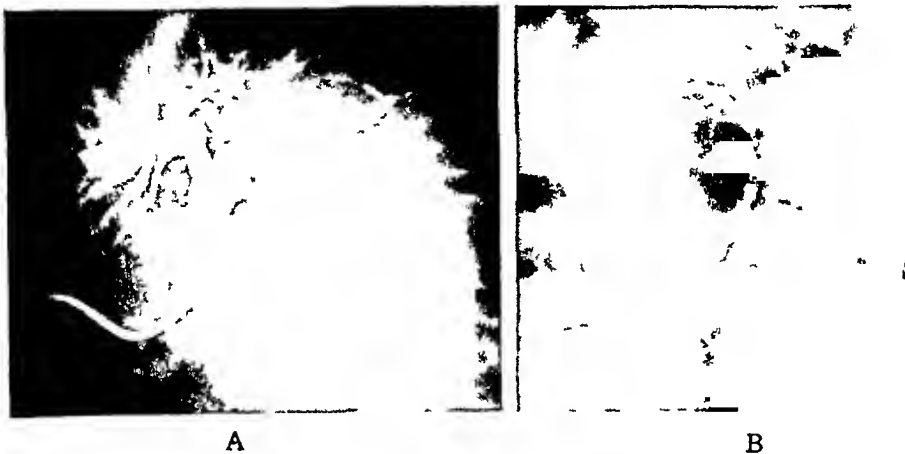


FIG 2 A Common duct drainage following cholecystectomy and removal of large stone from common duct. Delayed cholangiogram reveals stone in distal end of common duct. B After secondary operation stone removed and patent duct demonstrated

3 In cases of elective operations for chronic cholecystitis and cholelithiasis, the "immediate" cholangiogram can be used routinely without great difficulty or loss of time, by injecting the opaque medium through the cystic duct, the gallbladder, or the common duct

4 In anomalies of the ductal system encountered at operation an "immediate" cholangiogram, obtained by injecting the opaque medium through the cystic duct or gallbladder, should be used and will give the surgeon assurance and comfort by furnishing immediate visual demonstration of the ductal system

During our period of investigation we have routinely attempted, by one method or the other, to obtain cholangiograms of all gallbladder and common duct cases coming to operation. We have been encouraged by the results and convinced that greatly improved films can be obtained and our knowledge increased by simplification of the technic and improved equipment. Our series has not been sufficiently large to present convincing statistical data. We do wish to emphasize some points in technic and present a few typical cases

SURGICAL TECHNIC

A portable Bucky Diaphragm is routinely placed on the operating table between divided pads. It is necessary that all instruments be removed from the field before the roentgen-ray exposure, so it will save time if the towels are sutured to the peritoneum instead of using towel clips. The gallbladder and ducts are examined and exposed in the usual manner. The cystic duct is well exposed, and a ligature placed around it for later tying. A small transverse incision is made into the cystic duct and a #6 ureteral catheter is introduced. Its introduction will be facilitated by leaving the small wire stylet in the catheter until after it is in position and secured by the ligature



FIG 3 Acute Cholecystitis. Common duct slightly enlarged and induration about distal portion. Cholecystectomy. Immediate cholangiogram indicates normal and patent duct.

around the duct. The opaque medium is injected from a 20 cc Luer-Lok syringe through an appropriate size needle placed in the proximal end of the catheter. The use of the long ureteral catheter allows the surgeon to be entirely out of the roentgen-ray field and permits control of the rate and quantity of the injection. After the serial films are obtained, the cystic duct is completely cut across above the ureteral catheter, which is allowed to remain in place. The removal of the gallbladder is completed while the films are being developed, so that there is a minimum loss of time. If the films are satisfactory, the catheter is removed and the stump of the cystic duct is transfixed and ligated in the usual manner. If additional films are desirable, they can still be obtained at this stage of the operation.

We have found that 35 per cent diodrast is the most satisfactory contrast medium, and have not encountered any complications in its use. Lipiodol is a very unsatisfactory contrast medium. Hippuran is also a very satisfactory contrast medium, but we have seemed to obtain better results with diodrast.

ROENTGEN-RAY TECHNIC

The roentgen-ray equipment used at the operating table consists of a Bedside unit, 110 peak K V and 20 M A.

A Leisholm "wafer" grid was employed on the earlier cases, in which instances, the roentgen-ray factors were 30" distance, 20 M A 1.75 to 4.5



FIG 4 A Chronic Cholecystitis Cholelithiasis, and Cholecystectomy
B Examples of immediate normal cholangiograms

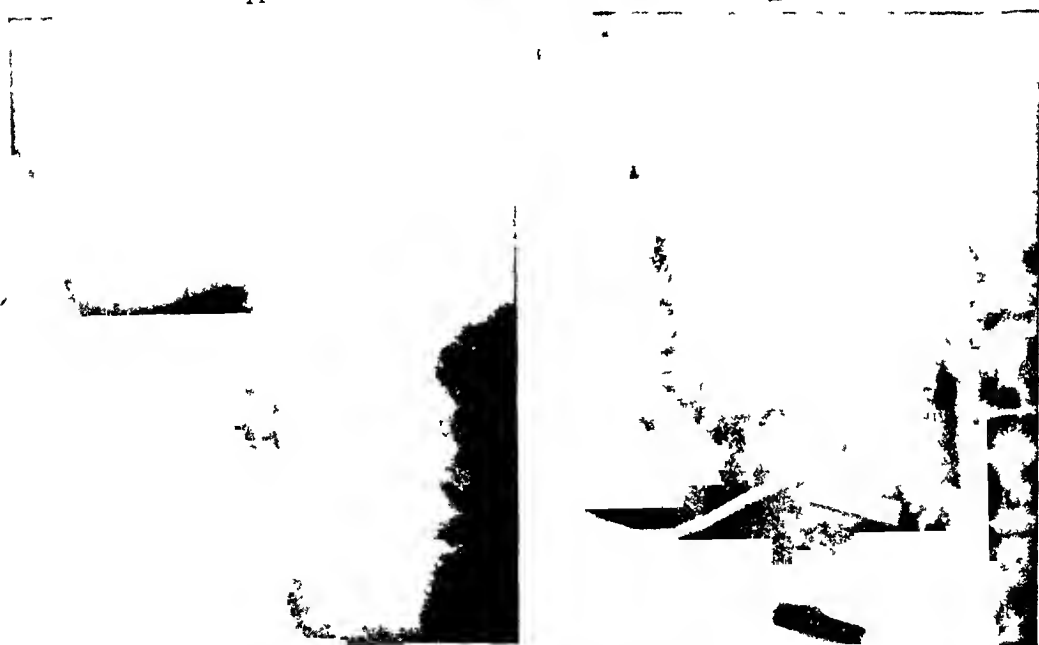


FIG 5 A Chronic Cholecystitis, Cholelithiasis Cholecystectomy Immediate cholangiogram reveals the six stones within the common duct B Common duct drainage same case reveals duct without obstruction

seconds exposure The prereading voltage was 110 K V , during exposure this reduces to actually 98 K V The time factor varies according to the thickness of the individual

In our later cases a 36-inch 6 1 ratio Bucky was used This has now been changed to a 30-inch 6 1 ratio Bucky, so as to employ a shorter distance and exposure time

Film are ordinarily made following the instillation of 5 cc , 10 cc and 15

cc of the opaque substance. If indicated an examination is made 5 to 10 minutes later.

In postoperative cases, where a drainage tube is in place, an effort is made to empty the biliary tract simply by releasing the clamp. Exposures are then made after injection of 5 cc, 10 cc and 15 cc of the opaque substance, stopping immediately if the patient complains of pain in the upper abdomen or back. The examination is carried out in the anteroposterior position, occasionally stereoscopic and right lateral views are made. These have not given additional information.

The postoperative examination produces technically better films more consistently than those made at the operating table. The greatest difficulty experienced while making film during the operation has been in controlling respiration while making the roentgen-ray exposure.

CONCLUSIONS

I Delayed Cholangiograms should have routine use in all cases of common duct drainage and biliary fistula.

II Immediate cholangiograms are a valuable adjunct to present surgical technique.

III Immediate roentgen-ray visualization of the common duct may be obtained in any desired case if routine preparation is made for the procedure.

IV Better films and more accurate interpretation will be obtained when roentgen-ray units of higher amperage are available in the operating room, thus allowing shorter exposures and better control of respiration.

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ACUTE CHOLECYSTITIS*

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THE IRRREGULARITY AND SURGICAL IMPORTANCE of acute cholecystitis warrant continued study and discussion of the problem. With increasing life expectancy, we can expect greater incidences of all phases of biliary tract disease. Probably no other intra-abdominal disease is handled so casually in its early stage as is this surgical emergency. Many general practitioners and internists favor the conservative treatment of the disease, recalling similar cases which have regressed with 'watchful waiting'. This is particularly true when patients have had previous acute episodes which subsided spontaneously. It is not appreciated that each acute attack increases the mortality by approximately two per cent. Too, they are relatively unaware of the dramatic reduction in morbidity and mortality in gall-bladder surgery during the last decade.

It is all too easy to forget that advanced acute cholecystitis is infinitely more serious than is the disease in its early stages. One of the greatest arguments against conservative therapy is that its practice by surgeons has led to widespread observation of acute cholecystitis by general practitioners and medical men. This obviously allows the disease to progress to a dangerous state in many instances before surgical treatment is sought. Only too often the initial therapy is carried out in the home where close observation is usually not feasible. Education of our fellow physicians to regard acute cholecystitis as as much of a surgical emergency as acute appendicitis would, in our opinion, reduce the present mortality and morbidity by at least one-half. The ruptured appendix (fortunately less frequently encountered now) is, usually, the result of home remedies and purgation, yet the complications of acute gallbladder disease which we see are most often due to the practice of so-called conservative therapy by physicians.

The reluctance to regard acute cholecystitis as a "surgical emergency" reminds the senior author of the slow acceptance at the turn of the century by the medical profession of early operation in acute appendicitis. It is a paradox that we are so universally agreed on the therapy of acute appendicitis and yet diverge so sharply in treatment of acute cholecystitis.

ETIOLOGY

The obvious fallacy of regarding all inflammation as due solely to bacteria resulted in the common acceptance of infection or bacterial invasion as the primary etiologic factor in acute cholecystitis. This was further substantiated by the experimental production of gallbladder inflammation by injecting streptococci into the portal circulation (Rosenow). The late Edmund Andrews was one of the earliest observers who pointed out the discrepancies

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in the infectious theory. Careful culturing of the bile and gallbladder walls in normal, chronically diseased, and acutely inflamed gallbladders revealed little difference, quantitatively or qualitatively. The failure of correlation between the presence of bacteria and the pathologic findings raised serious doubts as to the bacterial etiology of acute cholecystitis. That the primary injury may be chemical was substantiated by Mann's producing acute cholecystitis by the intravenous injection of Dakin's solution. Andrews *et al* were able to reproduce a picture clinically indistinguishable from acute cholecystitis by injecting bile salts into the gallbladder.

Womack⁵⁷ has emphasized the importance of the following factors in the pathogenesis of acute cholecystitis: (1) obstruction of cystic duct, (2) action of entrapped bile on the gallbladder wall and (3) the occasional secondary bacterial invasion, superimposed on chemically damaged tissue. This view was substantiated by experiments on dogs where obstruction of the cystic duct without removal of the gallbladder bile resulted in acute inflammation, varying in severity in direct proportion to concentration of cholesterol and bile salts. Identical cystic duct obstruction with replacement of the gallbladder bile with saline resulted in no corresponding inflammation.

COURSE

The usual initiating factor in the production of acute cholecystitis is cystic duct obstruction, this obstruction in 95 per cent of cases is due to an impacted calculus, although obstruction from congenital abnormality or inflammatory edema is occasionally encountered. Kiernan³⁵ reports four in a series of 102 cases of acute cholecystitis in which obstruction was not due to stones. As long as the obstruction persists, the disease is a progressive one, for the intravesical pressure increases from secretion, exudation and transudation. This increased tension may be so marked as to produce vascular interference with consequent gangrene and resultant perforation with peritoneal soiling. In 80 to 90 per cent nature will interrupt the cycle by relieving the obstruction—i.e. by dislodgement of the stone into the gallbladder or by passage into the common duct. Thus, in at least 10 to 20 per cent, surgical interference is absolutely necessary if perforation is to be avoided.

The crux of the argument of the conservative school is the ability to determine, clinically, which course of events is ensuing. Yet, the admitted lack of parallelism between the clinical findings and the underlying stage of pathology makes "watchful waiting" fraught with danger. In a revealing discourse, Touroff⁵³ reports 75 cases of pathologically proven acute cholecystitis, 52 of which were entirely free of clinical manifestations and 23 with only minimal signs or symptoms. Despite the paucity of clinical findings, many of the cases had empyema, gangrene and even perforation! Eliason and Stevens¹⁶ emphasize the disparity between pathologic and laboratory-clinical findings. In 135 cases of pathologically proven acute cholecystitis, 21 per cent presented no abnormality of the leucocyte count, 23 per cent had a normal temperature and 4 per cent had no tenderness whatsoever. In any given case, accurate

determination of the exact nature and extent of the underlying stage of pathology is clinically impossible

Proponents of watchful waiting exploit the fact that 80 to 90 per cent of acute attacks will subside at the expense of the unfortunate 10 to 20 per cent who fail to do so. Regarding acute cholecystitis as a progressive obstruction in which it is frequently impossible to determine the stage of the disease would be a much more logical plan. Certainly a disease which can disguise its acuteness so effectively should be regarded with great concern. Conservatism should be more accurately designated as "wishful waiting" instead of watchful waiting."

TREATMENT

Review of the American literature of the past 15 years reveals an increasing skepticism of conservatism in the management of acute obstructive cholecystitis. Twenty years ago, the *rationale* of conservative treatment was not so greatly questioned. In the past decade the pendulum has swung decidedly towards early operation. Evidence has been accumulated which demands serious consideration of surgery in every case. 'Clinical impression' is too inexact even in the best hands. That this is true is borne out by the frequent finding of gangrene, empyema and perforation—often without significant variations in temperature, blood count and clinical findings. Fallis and McClure¹ report an incidence of 15.9 per cent gangrene and perforation in a series of 320 cases of acute cholecystitis. Cowley and Harkins,¹⁰ in a collected series of 2,261 cases of acute gallbladder disease, found an average incidence of perforated gallbladder of 13 per cent. The frequency of gallbladder rupture in acute cholecystitis is often obscured by writers of the conservative school who quote figures of 1 to 3 per cent which are derived by considering all cases of cholecystitis, whether acute or not. Heuer,²⁹ in an exhaustive study of personal cases and the literature concluded that at least 20 per cent of cases of acute cholecystitis will have the complications of gangrene, abscess or peritonitis if a policy of inactivity towards the disease is used. All agree that such complications markedly increase the seriousness of the disease—mortalities from 20 to 52.2 per cent are found in the literature. Heyd,³⁰ after repeated observations, states that acute cholecystitis is by no means "so benign or self-localizing a lesion as was formerly believed."

Wallace and Allen,⁵⁴ in a most comprehensive study of 415 cases of acute cholecystitis at the Massachusetts General Hospital, found gangrene present in 29.4 per cent of all cases, over half of these cases presented perforation three had generalized peritonitis. In their series, perforation increased the mortality from 5.3 per cent to 17.2 per cent. These authors were unable to find any reliable criteria to indicate perforation and gangrene—30 of their cases suffered perforation while being observed in the hospital. Miller,⁴² in 1930 at the same hospital, had emphasized that the general principle of operation on septic processes without undue delay held true for gallbladder disease. Glenn^{23, 24} has been one of the foremost advocates of early operation. At the

New York Hospital, the policy has been to operate upon all patients after adequate preparation unless there is some serious contraindication which is not immediately reparable. During a 13-year-period, 527 patients have been handled in this fashion with only 13 deaths—an enviable mortality rate of only 2.4 per cent. Heyd³⁰ reports the lowest mortality and morbidity in those patients operated on within four days of the onset of their illness after a period of 6 to 24 hours hospitalization for preparation. Hotz³³ regards the policy of watchful waiting as a “gamble unjustified by the end results,” finding 9.2 per cent of all patients operated on for acute cholecystitis to have perforation with peritonitis. His study shows only 23 per cent of these proved perforations to be definitely localized at the time of operation. Lester,³⁷ utilizing early operative interference, reports a mortality of less than 2 per cent in a series of 109 cases of acute cholecystitis. MacDonald³⁸ advocates utilization of a two-stage procedure—cholecystostomy during the acute stage and cholecystectomy as an interval procedure. He emphasizes that this is a logical plan in that it allows early relief of the obstructive element, which is rational treatment for any abdominal obstruction. He points out that decompressive procedures have well proved their worth in obstructions of the bowel.

Stone and Owings,⁵⁰ in a classic discussion given before the American

on an acute gallbladder as acute appendicitis or ruptured ulcer, although admittedly, gallbladder perforation had a much better chance of walling off. They urged early surgery, pointing out that it would result in notable saving of time, expense and danger. On the same program, Judd and Phillips³⁴ subscribed to the plan of early operation but urged careful individualization of all cases. Despite the decided trend towards early surgical interference, there are many who just as strongly favor delayed intervention. Pennoyer⁴⁴ believes the dangers of surgery in the acute phase are greater than the danger of the natural course of the disease. In analyzing the reports of many who statistically support the school of conservative therapy, one is struck with an obvious disparity—only the fulminating cases are subjected to early operation in their series. Then the results in the less severe cases, which are handled conservatively, are compared to the group of fulminating cases in which early surgical intervention was necessary. Obviously, such statistics are grossly misleading as they compare different stages of the disease process.

PROGNOSIS

The most important factors in the ultimate outcome are the age of the patient, duration of the acute episode, number of antecedent acute attacks and duration of chronic biliary tract disease.

That the mortality is considerably higher in the older patients has been repeatedly stressed. It is not appreciated that the elderly are more prone to develop gangrene and perforation and that early operation is especially indicated in this group. This increase in complications of acute gallbladder disease is the result of longer standing pathology with more infection in the

biliary tract and a greater degree of resultant liver damage coupled with a lessened vascular reserve, locally Glenn¹¹ reports a five-fold increase in mortality after the age of 50—5.14 per cent as compared to 1.13 per cent in patients under 50. Eliason and Stevens¹⁶ report the mortality after 60 to be 8 to 10 times the mortality prior to this age. Fallis and McClure¹⁰ had only one death in 108 patients below 40, or a mortality of 0.9 per cent, but had five deaths in 48 patients 60 and above, with a mortality of 10.5 per cent.

The factor of duration of symptoms is of the utmost importance, for complications—gangrene, pericholecystic abscess and peritonitis—are more frequent after the first 72 hours. Delay increases the chances of obstructive jaundice and allows for prolonged liver damage. All agree that these complications are conducive to increased mortality and morbidity. One cannot help but be impressed with the technical feasibility of operation and smooth convalescence following removal of an acute gallbladder in the early stage of the disease.

RESULTS OF QUESTIONNAIRE

Realizing the subject of acute cholecystitis to be a controversial one, aid was sought from the various members of the Southern Surgical Association. A gratifying questionnaire response was obtained, for 151 of the group doing general surgery reported. Although admittedly difficult to answer such questions briefly, the following results were obtained:

Question I—In acute cholecystitis, do you favor early or delayed operation? Of the 151 general surgeons queried, 101, or 66.8 per cent, favored early operation, while 38, or 25.1 per cent, preferred delayed surgical intervention. Twelve members, or 8 per cent, did not associate themselves with either group, pointing out that individualization of cases decided the issue.

Abell¹ remarks that he has "long been an advocate of early operation in acute cholecystitis, this position resulted in watching several patients go from bad to worse in subsequent gallbladder gangrene, perforation, sub- and intra-hepatic abscess and pancreatitis." Stone⁵¹ emphasizes that he is a "strong believer of prompt operation in this condition." Boland⁵ states that he has "never regretted operating on an acute gallbladder." Royster⁴⁷ points out that early operation worked so well when he was a recent patient with acute cholecystitis, that he now, more than ever, is an advocate of early intervention. Anglem, Carter, Cole, Estes, Finney, Gage, Goode, Longmire, C. W. Mayo, Ochsner, Rankin and Rienhoff are among those favoring early definitive surgery in acute cholecystitis.

Womack⁵⁸ and the Barnes Hospital group withhold surgery in most instances of acute cholecystitis unless there is evidence of progression rather than subsidence of the disease. McClure³⁰ urges conservative treatment and emphasizes the importance of following prothrombin studies and liver function tests carefully. Dinsmore¹² believes the dangers of delayed operation have been over-emphasized. Rives⁴⁶ prefers delayed or interval surgery unless the sever-

ity of the process does not permit. Other advocates of "watchful waiting" include Curtis, David, Guthrie, King and Venable.

Although it is clearly evident that this controversial problem has not been settled, there has been in the last fifteen years an unquestionable trend toward early (though not immediate) intervention.

Question II—In general, is cholecystectomy or cholecystostomy your procedure of choice?

If technically feasible and the patient is in reasonably good condition, cholecystectomy was overwhelmingly favored as the procedure of choice. Only 4 of 151 practice routine or usual cholecystostomy, 3 of this 4 are proponents of delayed surgical intervention. Drainage only is practiced by most of the group in the very elderly and extremely ill patients and when the local pathology is so advanced as to make identification of vital structures difficult. Many advocate cholecystostomy in severe diabetics. The method of partial cholecystectomy first suggested by Denegre Martin is not infrequently used in the severe cases. Heyd³² favors cholecystectomy by a similar technic: division of the gallbladder from the fundus to the cystic duct with complete enucleation of the mucosa. The incision is then sutured and a rubber tube introduced. He classifies the immediate result as a cholecystostomy, the ultimate result is obliteration of the gallbladder. Penick⁴³ advocated early cholecystectomy but advises cholecystostomy if operation must be done between 72 hours and ten days. Rankin⁴⁵ also favors removal of the gallbladder but states, "I am not ashamed to do cholecystostomy and believe I have saved many lives with this procedure." Mahon⁴⁰ is content to do gallbladder drainage *in selected cases* "without embarrassment or apology." Cholecystostomy is usually accepted as a compromise, but life-saving procedure. There is little doubt that it produces a clinical cure in a small, but appreciable, percentage of cases. Especially is this true in those patients in whom there is a single large stone impacted in the cystic duct with minimal damage to the gallbladder wall. Donald¹³ finds -ostomy curative in a large per cent of gangrenous gallbladders and utilizes it frequently in patients of increased risk.

Question III—Do you advise concomitant choledochostomy?

Agreement was again manifest in the answers to this question, for the usual response was—"rarely," "not routinely by any means" and "only when definitely indicated." The majority explore the duct only when jaundice is present, palpable stones are evident, the duct is thickened and unquestionably dilated, and in the presence of a moderate to marked associated pancreatitis. Some few routinely aspirate the common duct and explore it when abnormal bile is obtained. A smaller group advises choledochostomy when small calculi are present within the gallbladder. As most cases of true acute cholecystitis are secondary to cystic duct obstruction, there is usually not associated disease of the common duct. Allen² believes choledochostomy indicated in less than 10 per cent of acute cases. Goode,²⁵ however, utilizes choledochal exploration in approximately 30 per cent of his cases. Gatch,²² on the other hand, believes

opening the common duct in the presence of acute cholecystitis is often dangerous

Question IV —Do you recognize a critical period in which surgery seems contraindicated?

Unfortunately this question was a bit too ambiguous and some declined to generalize about it. However, the following critical periods were emphasized.

(1) Period of dehydration and electrolyte imbalance. Although many were strong proponents of early operation, all were even more emphatic opponents of immediate operation. The importance of adequate preoperative reparation in which fluid, chemical and protein balance are restored was repeatedly emphasized. Such preparation can usually be accomplished in a few hours (usually 6 to 12).

(2) From 72 hours to 7 to 10 days after onset of acute attack. The dangers of this period were forcefully emphasized by many. The technical difficulties at operation were notoriously greater during this period. Allen² states, "The mortality was higher in our cases when the operation was undertaken between the 4th and 12th days after attack began. We, therefore, wait, if one can, until the attack subsides entirely unless we can get the patient in condition for surgery before the fourth day of disease." This view was supported by Burch, Gardner, Mixter, Ochsner, Owings, Penick and others.

(3) Definitely subsiding acute cholecystitis when first seen. Balfour, Churchill and Mayo stress the dangers of surgery in this period.

The beforementioned periods are the usual critical times recognized. All are not in full accord, however. Frank Glenn²⁵ admits the technical difficulties of late acute or subacute cholecystic disease, but advises early surgery in view of "The unpredictable course." Profound ante-mortem collapse is essentially the only critical period recognized by Stone.⁵¹

SUMMARY

Significant lowering of the still appreciable mortality in acute cholecystitis would be obtained by

(a) More widespread "prophylactic" biliary tract surgery. We are heartily in accord with the concept that there is no such thing as a "silent or harmless gallstone." As the future course is so unpredictable, all are to be regarded as potentially dangerous. This is especially true in the older age group where acute cholecystitis is such a severe disease. Such interval cholecystectomies should be done with a risk of less than one per cent. It is not unlikely that this risk is actually less than the danger of malignancy in a calculous gallbladder.²⁰

Although the Graham-Cole test has been one of the greatest advances in the management of gallbladder disease, too much emphasis is placed on actual visualization of positive or negative gallstone shadows. If intrinsic liver disease is reasonably excluded and the test properly done on several occasions with consistent failure of visualization of the gallbladder, surgery should be strongly

considered in all cases, as above 90 per cent of such cases will have biliary calculi

(b) Regarding biliary colic and acute cholecystitis as "surgical emergencies" This does not imply that such cases are to be operated on as quickly as appendicitis or ruptured ulcer. A period of preoperative preparation of four to eight hours is essential to restore electrolyte and fluid balance and carefully evaluate the patient. During this period the diagnosis can be definitely established. Early surgery is then indicated, this will obviate the gamble, which we consider unnecessary and definitely hazardous, of attempting to determine the course of a frequently progressive disease by clinico-laboratory methods. That a policy of diligent observation is an unsound one is accepted universally in acute appendicitis but is, unfortunately, a controversial one in acute cholecystitis. It is likely that 75 per cent of episodes of acute appendicitis will subside without primary operation, but no surgeon will sanction such treatment. Is it not a paradox that some of these same surgeons will observe the progress of acute cholecystitis on the basis that 80 to 90 per cent will subside?

General acceptance of early surgery as the treatment of choice in the acute gallbladder will obviously do away with the procrastination and casualness so frequently encountered in the early stage of the disease. Instituting operative therapy before the period of complications—empyema, gangrene and perforation—will, needless to say, dramatically reduce the morbidity and mortality of the disease.

Cholecystectomy will be feasible in above 90 per cent of the cases and is, without a doubt, the procedure of choice in trained hands. However, there will always be cases in which the general condition of the patient is sufficiently precarious or the local pathology so marked that identification of the vital structures is not feasible, this group should be handled by cholecystostomy. In severely ill patients, this may be a life-saving procedure and can be executed under local anesthesia practically without risk.

(c) Careful individualization of cases in the beforementioned critical periods

(1) When first seen. Parenteral fluids, nasogastric suction, sedation and, frequently, blood should be used. While early operation is ideal treatment, immediate surgery is often unjustified and dangerous.

(2) From the 3rd or 4th day to the 10th day after onset of the disease. This period is commonly recognized as having the highest morbidity and mortality. It is the period of advanced disease—the time of systemic depletion, impaired hepatic function and local complications, pericholecystic abscess and peritonitis. It is the period to be avoided by instituting early surgery. Careful individualization is essential. In contrast to the first 72 to 96 hours in which all cases should be considered seriously for early surgery, this period should be approached with a more conservative attitude. If the disease fails to subside or becomes progressive, then surgery is indicated. In this state of

advanced disease, cholecystostomy is often the procedure of choice and should be done without apology. It is infinitely better to do a safe drainage procedure than a heroic extirpation. Such advanced acute cholecystitis is the result of neglect, procrastination and "wishful waiting" and should best be treated by avoidance—i.e., early definitive surgery.

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DISCUSSION—DR WILLARD H PARSONS, Vicksburg, Miss It seems to me that the very informative paper of Doctor Barksdale and Doctor Johnston poses, among other possibilities, two important considerations First, should patients having acute cholecystitis be subjected to immediate surgical intervention, should they be treated conservatively so long as their condition continues to improve or, finally failing to improve, should they be subjected to exploration?

The essayists, in agreement with the many distinguished surgeons whom they quote, believe that patients having acute cholecystitis should be operated upon during the early phase of the disease The truth of the matter is that I do not, and I rather doubt that many of those present encounter a great number of patients having acute cholecystitis within the first 24 or 48 hours of its onset Perhaps education of general practitioners and of our medical colleagues will alter this situation Unless and until it does, surgeons will not have the opportunity of treating a great many patients for acute cholecystitis sooner than the second or third day of illness The authors quote Allen as stating that surgery is particularly hazardous between the fourth and twelfth days after the attack begins They further state that Allen advises waiting, if one can, until the attack subsides entirely unless the patient can be operated upon before the fourth day of the attack This seems to me sound practice and has been the course I have elected to pursue

The second question of concern presented by the essayists is the matter of whether or not patients having acute cholecystitis are apt to have stones in the common duct and, if stones are present, what should be done about them Everyone of experience agrees that the common duct should not be explored unless all the vital structures in that area can be identified For that matter, no operation on the biliary tract other than cholecystostomy ought to be done unless this is possible, and it is usually failure to do so that leads to disaster I had hoped the essayists would precisely record their personal experience in this matter, for Doctor Barksdale and I practice in adjacent communities and would perhaps expect to encounter about the same types of lesions in our practice

Of the last 100 consecutive patients on whom I have personally operated for disease of the biliary tract, 15 had acute cholecystitis clinically and pathologically Of this group one or two had gangrene of the gallbladder with perforation In 14 of the 15 patients, the gallbladder was removed, in one it was drained for various reasons and, a few weeks later, stones were removed from the common duct and the gallbladder was removed Seven of the 15 patients, or slightly less than 50 per cent, had stones removed from the common duct at the time of the primary operation

In other words, during this particular period of time, 15 per cent of the patients on my service having surgery of the biliary tract, had acute cholecystitis Of those having acute cholecystitis, essentially all had a stone, or stones, in the cystic duct and 50 per cent

had stones in the common duct. Of this group of 15 patients referred to, fortunately none died.

Reducing the affair to a practical basis, it would seem to me desirable to educate general practitioners and internists to the necessity of promptly requesting surgical consultation for patients having acute cholecystitis. It would further seem proper if one encounters, during the early phase of the disease, a patient with acute cholecystitis, to remove the gallbladder and do such other procedures as might be prudent and indicated. The majority of patients having acute cholecystitis are not encountered early in the course of the disease and these patients, I believe, ought to be treated conservatively, provided their condition improves, until after the critical phase of the disease has passed. They may then be subjected to appropriate surgery with increased safety.

DR HUBERT A. ROYSTON, Raleigh, N. C. I was very grateful to Doctor Barksdale for including me in his questionnaire. I thought I might answer his questions best, if I appeared in person as a witness and as Exhibit A. Since the last meeting of this Association I have been through all the stages of the disease that Doctor Barksdale has described. Many years ago I was imbued with the idea that acute inflammation of the gallbladder should receive immediate surgical attention. But I was very timid about it and I presented a short paper on "Should We Operate on the Acutely Inflamed Gallbladder?" I was impressed by this because, when you got a patient who had been through the acute period, after four or five days operation was easy, the gallbladder could be peeled out like a banana from its skin. On the other hand, appendicitis and cholecystitis in the acute forms are not wholly analogous, because in the former rupture and gangrene are very frequent. But I still think these conditions in the gallbladder are rare.

I was seized with intense pain which let up in about a week, at the end of that time I was operated on, the surgeon finding acute empyema of the gallbladder with intense edema throughout the biliary tract (as I understand it, I did not have a mirror)—intense edema, which is a serious complication. The surgeon drained my gallbladder and after a long siege of drainage of pure bile the gallbladder was subsequently removed. In addition, of course, they tied my superficial femoral veins and also had me practice, in my own way, early ambulation. I had already stuck out my neck about that, so I had to practice what I preached.

In addition six months later, I still have some pain at 5:00 A. M. and 5:00 P. M. I used to wonder why my patients had that, and now I understand. I expressed to Doctor Barksdale the procedure which I think we should adopt. Cholecystectomy, if you can, cholecystostomy, if you must. In surgery there is many an "if-and-but", also an occasional "and/or" and often a "whether-or-not", which reminds me of the preacher who gave out notices at the Sunday morning service. Said he "On Wednesday night there will be the usual prayer meeting, God being willing. On Friday afternoon there will be the annual Sunday School picnic at 3:00, whether or not."

DR MALCOLM THOMPSON, Louisville, Ky. The limitations of time prevent, I regret, my discussing more than one of these excellent papers, so my remarks will be confined to the subject of gangrenous cholecystitis. As Doctor Barksdale has told us, gangrenous cholecystitis is a serious condition requiring surgical operation early in its course.

In operating upon a patient with gangrenous cholecystitis the surgeon is motivated by two desires. The first is to remove all the necrotic tissue which, if permitted to remain, will act as a focus for the continuation of peritonitis. The second is to avoid opening new avenues of infection, biliary contamination, and hemorrhage, while removing the diseased tissue.

Although classical cholecystectomy will remove all the diseased tissue, it opens up new planes for infection and may lead to hemorrhage from the hepatic bed in a patient poorly prepared for such loss of blood or added injury. Although drainage alone will not promote spread of the infection nor lead to undue hemorrhage, it does not afford removal

of all the diseased tissue, nor will it ensure against a recurrence of the disorder should the patient survive. In addition, cholecystostomy alone is often inadequate because if the gangrenous process has not already involved the entire gallbladder it may do so later.

Doctor Barksdale has mentioned Doctor Martin's contribution. In 1922, at the Memphis meeting of this Association, Dr. E. D. Martin of New Orleans described for the relief of gangrene of the gallbladder what he called a compromise between complete excision and drainage, in which he opened the gallbladder to the cystic duct and removed the mucosa by the use of curettage and escharotics. This was followed by drainage of the remaining portion. This method of Doctor Martin's avoided the undesirable features of cholecystectomy while retaining the feature of removal of the diseased portion and left, upon recovery, a harmless fibrous cord. Subsequently, Doctors Gatch, Estes, Heyd, and Pribram reported similar methods.

After hearing Doctor Martin, Doctor Abell modified the procedure somewhat and has used it since when the occasion presented. As now performed, that portion of the gangrenous gallbladder which is not intimately attached to the liver is excised with a sharp instrument to the origin of the cystic duct. Bleeding points, which are usually only one or two, are ligated individually with a suture type ligature. That portion of the mucosa remaining upon the hepatic attachment of the gallbladder is removed from its bed by sharp dissection. The fibromuscular coat remains upon the liver and from it receives enough blood to survive. The operation is completed by insertion of a soft drain to the orifice of the cystic duct which, in my experience, has not been involved in the gangrenous process as it receives collateral circulation from the vessels in the duodeno-hepatic ligament.

Those of us who have profited in countless ways from Doctor Abell's teaching and example can assure you that this is a most satisfactory procedure and is, I believe, the one of choice for treating gangrenous gallbladders. Those of you who have yet to perform it for the first time will be pleased, as I was, at the ease and rapidity with which it can be done, the relatively small amount of bleeding, the smooth convalescence provided there is no serious complication, and the permanence of relief.



FIG 1

Figs 1 and 2—Slides demonstrating findings



FIG 2

DR CHARLES M EDLIN, Louisville, Ky I have enjoyed the papers of Doctors Hagan and Barksdale It has been my pleasure to have assisted Doctor Hagan on many of his cases In the method just described he has materially reduced the usual delay incidental to obtaining a direct cholangiogram during the surgical procedure

Only recently an occasion arose in which I was greatly relieved by the cholangiographic findings In the course of a simple retrograde cholecystectomy I encountered an anomalous cystic or aberrant duct At first glance I thought I had tented and removed a segment of the common duct Further exploration, however, fortunately for the patient and myself, proved this not to be the case An immediate cholangiogram gave additional confirmative evidence for which I was most grateful

The two slides I would like to show demonstrate our findings (Figs 1 and 2, Page 827)

DR J W BARKSDALE, Jackson, Miss (closing) I regret that I have not the figure in percentages of calculi in the common duct In some desperately ill and aged patients where the time factor was a desideratum greatly to be desired, no attempt was made to discover the presence of stones Realizing that in this class of cases life hangs by an exceedingly tenuous thread the effort has been made to compromise by doing the least possible surgery It has been thought better in some instances, should it become imperative, to postpone to a later date operation on the common duct

In reading the paper, time did not permit dwelling *in extenso* on the Martin method of cholecystectomy In many instances it has obvious advantages and is often a life-saving procedure By carefully attempting to evaluate each individual case and to follow such procedure as might be indicated in a particular case, we have had no deaths in our gallbladder surgery in the last 318 cases

DR J HARVEY JOHNSTON, Jackson, Miss (closing) While serving as residents at Charity Hospital in New Orleans, Dr R B Brunazzi and I studied with Dr Alton Ochsner the records of all patients with clinically and pathologically proven acute cholecystitis for the five-year period prior to January, 1946 This hospital is unique in actually being three hospitals in one Although the medical and clinical facilities are identical, each service is an independent one with its own policy of practice An excellent opportunity for a controlled comparison of results in acute cholecystitis was offered, for one service favored early operation and another practiced delayed intervention

The study comprised 140 cases of unquestionable acute cholecystitis both from a clinical and pathologic standpoint, 54 per cent were treated by early operation, 46 per cent by observation with operation only when the disease failed to regress In analyzing the clinical picture it is important to note that 25 per cent failed to present leukocytosis and only 30 per cent had admission temperatures exceeding 100.4 degrees, while 95 per cent presented pain and tenderness Palpable mass was found in 40 per cent Thus, I believe it is a mistake to wait for the development of fever, leukocytosis, and palpable mass before making a clinical diagnosis of acute cholecystitis

More advanced pathology was found at operation in the delayed operation group, 22.5 per cent empyema as contrasted to 10.5 per cent in the early operation series, rupture with localized peritonitis in 6.5 per cent as compared to 3.9 per cent Although I have heard several outstanding men say they have never seen a case of generalized peritonitis as a result of acute gallbladder disease, there were five cases in this series of 140, an incidence of 3.6 per cent! Associated adenocarcinoma of the gallbladder was found in two, or 1.4 per cent

Morbidity studies showed that hospitalization averaged 30.5 days in the delayed group and 19.5 days in the early operation cases In those cases hospitalized within three days

of the onset of acute illness, mortality was 6.7 per cent in those cases submitted to early operation and 12.5 per cent in the patients treated expectantly. However, in the patients hospitalized more than 72 hours after the beginning of their illness, 18 per cent died if submitted to early operation, while 9 per cent expired when delayed surgery was practiced. Although the series is small, it is evident that early cholecystectomy is the procedure of choice in the first 72 to 96 hours of the illness. If operation is neglected during this period, it would seem much wiser to defer operation, if at all possible, from the fourth to the seventh day of the disease, as early surgery in this period had a prohibitive mortality.

The beforementioned mortality figures are higher than those usually encountered. This is due partly to the type of patient treated, but mainly to the rigid criteria each case fulfilled before being classed as acute cholecystitis. As we were earnestly trying to evaluate the conflicting types of therapy, all borderline cases were excluded.

A CLINICAL EVALUATION OF CHERNEY'S INCISION*

JOHN C BURCH, HORACE T LAVELY AND CLOYCE F BRADLEY

NASHVILLE, TENN

IN THIS COUNTRY, the usual surgical approach to the pelvic viscera is through a median suprapubic or paramedian incision. Our preference has been for the paramedian incision and usually the exposure has been adequate. However, many situations are encountered in which the operation could be facilitated by more exposure. This is because most of the structures in the depth of the pelvic cavity run perpendicular to the axis of the vertical incision and are located near its lower angle where retraction is limited by the attachment of the recti to the pubis. For these reasons, many continental surgeons have favored the Maylard or Bardenheuer incision.

This incision begins one to two fingerbreadths below and medial to the antero-superior spine and proceeds in a gentle curvilinear fashion to a point one or two fingerbreadths below and medial to the opposite antero-superior spine. All layers of the abdomen are divided in the plane of the incision. Exposure is facilitated as the transverse diameter of the lower abdomen is 25 per cent greater than the distance from the umbilicus to the symphysis. Since exposure is a function of the length of the incision, the transverse incision gives a field one and one-half to two times greater than the usual vertical one. It may be argued that lengthening the vertical incision will produce the same exposure. This, however, is not true as regards exposure of organs within the true pelvis, as exposure is limited by the bony framework of the pelvic inlet. Here again the greater transverse diameter of the true pelvis produces the same result of an increase of one and one-half to two times the exposure. In addition to the greatly increased exposure, the transverse incision is more efficiently used as the course of most structures is parallel to the axis of the incision, and in line with the eye of the operator.

The disadvantages of the Bardenheuer type of incision result from the anatomic features peculiar to the subumbilical region. When the rectus muscle is divided above the level of the tendon and below the entrance of the 11th and 12th thoracic nerves, the lower or pubic segment of the divided rectus is denervated. The absence of tendinous inscriptions in the subumbilical region allows the rectus to contract and separate the cut ends more widely than in the supra-umbilical region. Perhaps the weakest point of the incision is the absence of a well developed posterior rectus sheath at the level of the incision. At the time of closure of such an incision, the abdominal wall consists solely of the sutured peritoneum and the fascia of the anterior sheath. It is, therefore, definitely not as strong as a sutured rectus cutting incision in the upper abdomen. These anatomic disadvantages can readily be seen to favor the inci-

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Tuesday, December 9, 1947

dence of postoperative hernia and evisceration, although many observers state that this is not unduly high

In spite of its disadvantages, the continental surgeons have found the Bardenheuer incision useful and indicated in certain cases With few excep-

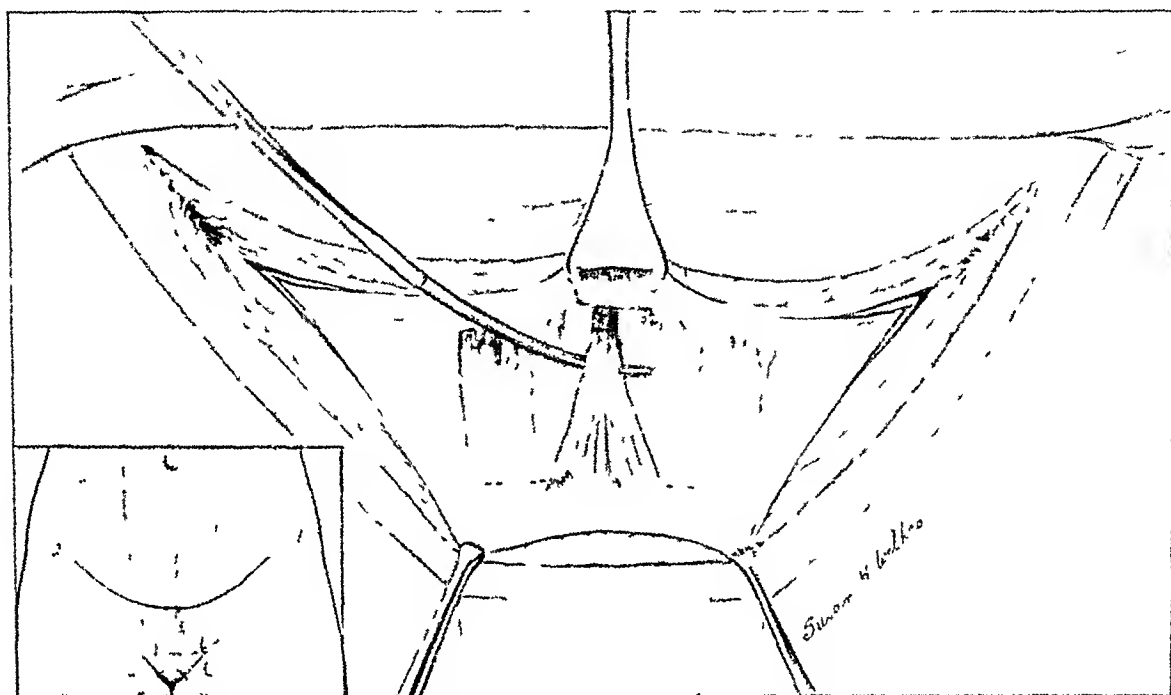


FIG 1—Lines of division of pyramidales and rectus tendons

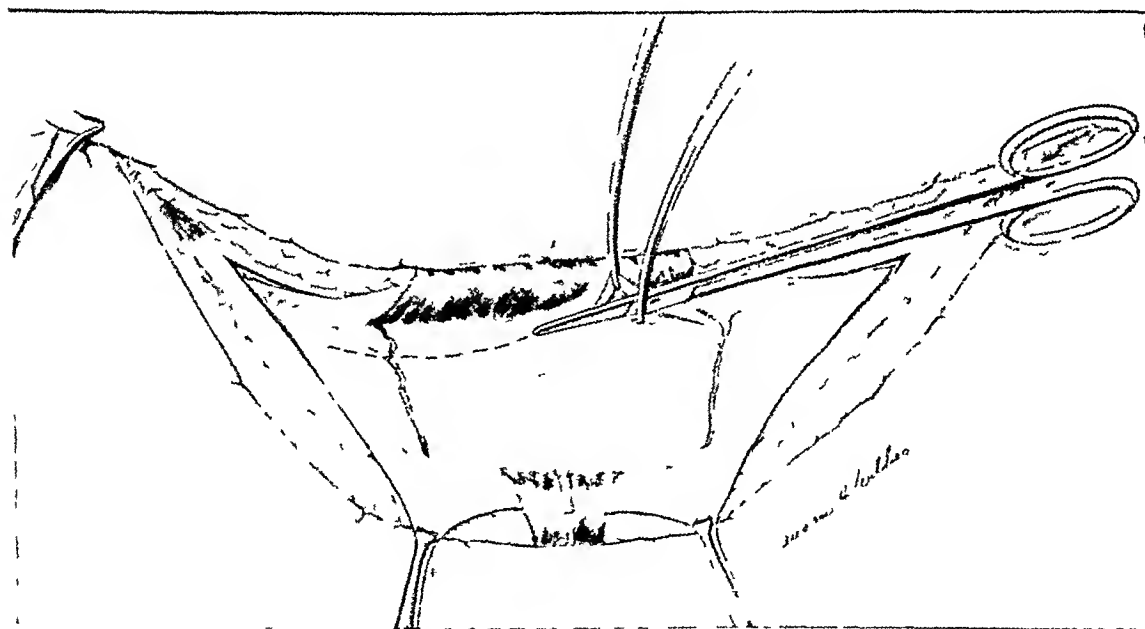


FIG 2—Transverse incision of peritoneum

tions⁴ most American surgeons know of it by name only This is probably due to the fact the Europeans have used it primarily for the radical operation for carcinoma of the cervix, and this operation has until recently been of infrequent occurrence among us A more radical attitude toward the problems of uterine malignancy and the tendency to resections and anastomosis in the

lower sigmoid and upper rectum have contributed to a desire for better than average exposure in the depths of the true pelvis. This need has expressed itself in a search for an improved transverse lower abdominal incision.

Cherney^{1, 2} presented a modification of Bardenheuer's incision which does much to overcome the anatomical disadvantages. This incision has been used by Fallis³ to advantage in resection of the rectum and by Smith⁵ for exposure

TABLE I

Diagnosis	Number	Per Cent
Fibromyoma Uteri	29	48.3
Endometriosis	7	11.6
Ovarian Tumor	4	6.66
Carcinoma of Cervix	3	5.0
Cephalo-Pelvic Disproportion	3	5.0
Ovarian Failure	3	5.0
Carcinoma of Fundus	2	3.33
Carcinoma of Sigmoid	2	3.33
Diverticulitis and Diverticulosis	1	1.66
Gangrene of Ileum	1	1.66
Intussusception	1	1.66
Stricture of Ileum (X-Ray)	1	1.66
Peritoneal Inclusion Cyst	1	1.66
Ureteral Calculus	1	1.66
Retroversion	1	1.66

TABLE II

OPERATION	NO	%
HYSTERECTOMY, COMPLETE	35	58.3
OOPHORECTOMY	4	6.66
MYOMECTOMY	4	6.66
HYSTERECTOMY, RADICAL (WERTHEIM)	3	5.0
CESARIAN SECTION	3	5.0
RESECTION SIGMOID	3	5.0
RESECTION SMALL INTESTINE	3	5.0
HYSTERECTOMY, SUBTOTAL	2	3.33
URETEROLITHOTOMY	1	1.66
EXCISION PERITONEAL CYST	1	1.66
SUSPENSION (OLSHAUSEN)	1	1.66

HYSTERECTOMY, ALL TYPES

(40)

of the lower ureter. Petit⁴ found it difficult to close. In spite of these opinions, there is little factual material in the literature based on any substantial number of cases. For this reason, it has seemed wise to us to call attention again to the incision and to present an analysis of 60 cases in which it has been used.

DESCRIPTION

The skin incision is made in a curvilinear fashion beginning from one to two fingerbreadths below and medial to the antero-superior iliac spine, crossing the midline, running almost straight and just within the hairline, and terminating below the iliac spine of the opposite side (Fig. 1). It is carried through the subcutaneous tissue down to the aponeuroses of the external oblique

muscle and the anterior rectus sheath. At either end of the incision the superficial epigastric vein is usually encountered, divided and ligated.

The anterior sheath of the rectus muscle is incised in the line of the skin and the incision is extended laterally through the aponeuroses of the external and internal oblique muscles, thus exposing the underlying recti with the transversalis fascia and peritoneum laterally. In the more central portion, the aponeuroses of the obliques are fused, but as the incision is extended laterally, two separate layers are recognized at the ends of the wound. The fleshy

TABLE III—*Morbidity*

Days	0	1	2	3	4	5	6
Number	19	13	12	12	2	0	2
Per Cent	31.7	21.6	20.0	20.0	3.3	0	3.3

Total Morbidity = 93 Days

Average Morbidity = 1.55 days

In this Study morbidity includes any day in which temperature exceeded 38°C (100.4°F) including day of operation

TABLE IV

Ambulatory	No	Per Cent
First Day	49	81.6
Second Day	8	13.3
Third Day	2	3.33
Later (6th Day)	1	1.66

TABLE V

Complication	Number	Per Cent	
Cystitis	3	5.00	} None
Atelectasis, Minimal	3	5.00	
Diarrhea	2	3.33	
Pre Vesical Hematoma	1	1.66	
Total	9	15.00	

fibers of the internal oblique muscle come into view under the aponeurosis of the external oblique. In exceptional cases the internal oblique muscle may be encountered more medially and may be split if necessary. The lower flap of the rectus sheath is grasped on either side of the midline and separated from the underlying recti by sharp dissection down to the pubic bones. The pyramidalis muscles are then dissected from the recti and the tendinous insertions of the recti are divided close to the pubic bones, allowing the recti to be reflected upward.

The peritoneal cavity is entered laterally and the incision is carried across one to two fingerbreadths above the reflection of the bladder peritoneum. The peritoneal incision usually extends from one inferior epigastric artery to the other. There is no contraindication to dividing one or both arteries (Fig. 2).

In closing, the peritoneum is sutured with interrupted sutures of #40 cotton. Curarization is a distinct aid in overcoming any difficulty in the closure.

The tendinous ends of the recti are reapproximated with interrupted sutures. It is much easier to place all these sutures before tying. The lateral ends come together easily. The method of tying is quite simple. The assistant approximates the tissues with the next to the end suture while the operator ties the end suture. This allows a knot to be set without tension as the strain is taken by the untied approximated suture more medially.

The pyramidalis muscles are then allowed to fall into place. The anterior rectus sheaths and the aponeuroses of the oblique muscles are then closed in one layer, care being taken to pick up both layers in the lateral portions of the wound. The subcutaneous tissue and the skin are sutured in the usual manner.

There were 60 cases in which this incision was used (Tables I and II). They represented a wide variety of pelvic lesions. Two-thirds of the cases were gynecologic. In these, a superior exposure was afforded by the incision. However, this wide exposure is not necessary for the usual gynecologic procedures. In the more difficult cases, the incision is a distinct advantage. Three of our cases had carcinoma of the cervix and were submitted to radical hysterectomies. These, as well as the one case of ureteral calculus in the lower ureter, illustrated the desirability of the incision for exposing the ureter in its terminal portion. In low cervical and extraperitoneal Cesarean section, the exposure of the lower uterine segment is accomplished more easily than in the customary vertical incision. There were two cases of carcinoma in the recto-sigmoid and one case of diverticulitis in the same region. All these were subjected to resection and anastomosis and all anastomoses were at or below the peritoneal reflection. Under ordinary conditions we have found this can be a trying procedure, but in these cases the anastomoses were easily done.

The convalescence of this diversified group of cases was remarkably smooth in spite of the fact that many were submitted to radical and extensive procedures.

In calculating morbidity, a day of morbidity was defined as any day in which the temperature exceeded 38°C (100.4°F), including the day of operation (Table III). In the entire series there was a total of 93 days of morbidity with an average morbidity of 1.55 days.

The patients in this series were allowed to walk as soon as their condition permitted. Of these, 81.6 per cent were walking on the first postoperative day and all except one were up and walking by the third day (Table IV).

There were no deaths and remarkably few complications (Table V). There were no wound infections. All wounds were securely healed and in satisfactory condition on the patient's discharge from the hospital. Unless otherwise indicated this occurred on the ninth postoperative day. All except six cases have been observed at periods ranging from one to ten months, and in no instance has wound weakness or herniation been noted. The recti were apparently intact in all. Three patients complained of some residual soreness in the lateral angles four months after operation. It was not unusual to see some

cutaneous hypesthesia within the arc of the incision. The single complication relative to the wound was the development of a prevesical hematoma which satisfactorily resolved. There were no cases of thrombophlebitis or pulmonary embolism in this small group.

SUMMARY

The Cherney incision offers marked advantages for the execution of difficult surgery deep in the pelvis. The wounds heal satisfactorily if properly closed. It is recommended as a distinct advance in those cases presenting problems of exposure.

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DISCUSSION—DR. JOE V. MEIGS, Boston: I rather hoped I would not have to discuss this paper. I have the greatest respect in the world for Doctor Burch and for this incision. We have tried a transverse incision cutting straight through the fascia and recti muscles. It is very easy to do and a perfect incision to operate through. After 150 cases I finally discovered a number of hernias. I have given it up, but my associate Doctor Parsons, still considers it satisfactory.

The Cherney incision, of which Doctor Burch speaks, cuts across the insertions of the recti into the pubes. We have used it and discarded it. For operations on the bladder or the lower end of the ureter it is perfect. We have done about 150 radical operations for cancer of the cervix, and in no instance have we had any difficulty in approaching the area of operation through the midline incision. It gives by far the best approach. I thoroughly agree that so far as convalescence is concerned the transverse incision is better. In young girls in whom we do not want to leave a scar the hairline Pfannenstiel incision is very satisfactory. No muscles are cut across and one can get plenty of room to do most pelvic surgery, including hysterectomy. For radical surgery I believe the midline incision is best.

DR. JOHN C. BURCH, Nashville, Tenn. (closing): I think in fairness it should be stated that the incision Doctor Meigs used is the Bardenheuer incision, and not the incision described. So far we have had no hernias, maybe we will get them. Certainly we have had them with the vertical incision. As to exposure, that is a matter of opinion. I am no stranger to the problems involved in radical surgery in the pelvis. In my opinion this incision, for my use in my way, has a distinct advantage. The reason for that is simple. When one is doing a radical operation or must operate deeply in the pelvis the structures at the bottom of the pelvis are in line with the eye, and it is not necessary to pull against the recti to get exposure. I grant it is more difficult to make and to close. It may have a higher incidence of hernias, but so far we have had none. When success of the operation depends on exposure, it deserves serious consideration.

"WET LUNG"—AN EXPERIMENTAL STUDY[†]

I The Effects of Trauma and Hypoxia

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"WET LUNG" or 'traumatic wet lung' are terms used to denote the accumulation of fluid in the lungs following accidental or operative trauma. This fluid may consist of blood, transudates, exudates or mucous in any combination. The term "pulmonary edema" is often used loosely to describe this picture. Edema in the strict sense implies an increase in interstitial fluid. However, as it has been applied to the lungs, it indicates the accumulation of pulmonary transudates within the air passages.

"Wet lungs" often are primary obstacles to recovery. Their treatment was of particular concern during the recent World conflict^{1, 2, 3}. The mechanism by which "wet lung" is produced is poorly understood. In these studies we have reproduced "traumatic wet lung" experimentally. The resultant changes have been studied.

I THE PRODUCTION OF EXPERIMENTAL WET LUNG

Methods—Twenty-one mongrel dogs were anesthetized with intravenous sodium pentobarbital in doses of 30 milligram per kilogram of body weight.

Trauma to the chest wall was produced in the anesthetized animal in two ways. Trauma was produced to the right hemothorax in all experiments. In all experiments the animal was fully anesthetized. In 14 experiments in this group a falling weight was used. In seven additional animals the right chest was shot in a tangential direction with a .45 calibre pistol as was described in a previous article⁴. The degree of trauma, established at autopsy, has been judged on two bases. First, the damage sustained by the thoracic cage, second, the damage sustained by the lungs. Four grades have been established and are used throughout this paper.

1 *Very slight*—no ribs broken—Pleura intact—Minimal hemorrhage into the adjacent lung without lacerations.

2 *Slight*—Simple fractures of one or two ribs—Pleura intact. Shallow lacerations of the lung, if any, with slight adjacent hemorrhage.

3 *Moderate*—Complete fractures of one or two ribs. Slight to moderate pleural tears. Lacerations of the lung often present. Hemorrhage involving approximately one-half of the directly traumatized lobe and often involving

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Equipment in the Lung Station of the Department of Medicine, a laboratory organized under a Grant from the Commonwealth Fund, was used in a part of this research.

adjacent lobes Occasionally slight hemorrhage posteriorly in the opposite (left) lung

4 *Severe*—One, two, sometimes three ribs shattered—Large pleural defects The directly traumatized lobe completely hemorrhagic, often to the extent that it assumed the consistency of the liver, and usually lacerated Adjacent lobes considerably involved with hemorrhage Hemorrhage posteriorly in the opposite (left) lung

In 13 of the experiments arterial blood samples were drawn from the right femoral artery for the determination of arterial oxygen saturation and the hematocrit Portions of nine were kept refrigerated under oil until the determination of oxygen saturation was made This was never more than five hours after the sample was obtained A portion of each sample was placed in an ammonium oxalate bottle for the determination of the hematocrit The first sample was obtained after anesthesia was induced, the second 15 to 20 minutes after the animal had been traumatized The third and final sample was drawn just before termination of the experiment The only exception is in the case of animal 58 (see Table I), in this instance the third sample was obtained at 24 hours

Arterial oxygen saturations were determined according to the method of Van Slyke and Neill⁷ The hematocrits were determined in Wintrobe hematocrit tubes

The animals remained on dog boards in the anesthetized state throughout the short-term experiments In the experiments which were continued for 24 to 72 hours the animals were allowed free movement and access to food and water after reacting

All animals which did not die as the result of trauma were sacrificed with large intravenous doses of sodium pentobarbital sufficient to produce almost instantaneous death In the early experiments the lungs were removed at autopsy with clamps on each hilus Each lobe was individually tied off, cut free, and weighed These weights were expressed in terms of per cent of body weight These ratios were found to correlate well with the amount of fluid present in the bronchi, observed at autopsy The practice of weighing each lobe was, therefore, soon discontinued

The amount of fluid present has been graded for each lobe on the basis of the amount exuding from the cut ends of the bronchi with gentle pressure These observations are recorded in Table I as follows

- 1 Very slight
- 2 Slight
- 3 Moderate
- 4 Considerable to excessive

The figures recorded in Table I are the approximate averages for all lobes of both lungs

The abdomen was opened at autopsy in all experiments to determine the extent of intra-abdominal injuries

TABLE I—The Production of Wet Lung by Trauma

Animal No	Agent Used to Produce Trauma	Time Interval Between Trauma and Termination of the Expt	Cause of Death	Degree of Trauma	Amount of Pulmonary Fluid	Arterial Oxygen Saturation (Vol's %)			Hematocrit (packed cell volume)		
						1	2	3	1	2	3
13	Weight	15 Minutes	Trauma	3+	25+						
14	Weight	26 Hours	Sacrificed	3+	25+						
15	Bullet	26 Hours	Sacrificed	3+	25+						
16	Bullet	20 Minutes	Trauma	3+	25+						
17	Bullet	28 Hours	Sacrificed	2+	15+						
18	Weight	27 Hours	Sacrificed	2+	10+				46	40	46
19	Weight	15 Minutes	Trauma	3+	20+						
20	Weight	4 Hours	Sacrificed	4+	30+	9 09	7 01	8 81	33	29	33
21	Weight	4½ Hours	Sacrificed	2+	15+				43	40	48
22	Weight	4½ Hours	Sacrificed	3+	20+	13 12	11 12	15 45	38	38	40
23	Weight	4½ Hours	Sacrificed	3+	25+				44	48	41
26	Weight	5½ Hours	Sacrificed	4+	30+	13 23	6 23	10 00	41	37	35
27	Bullet	4½ Hours	Sacrificed	1+	05+	12 12	10 73	12 00	31	31	33
28	Bullet	4½ Hours	Sacrificed	4+	30+	9 81	4 53	9 15	30	29	25
29	Bullet	4½ Hours	Sacrificed	4+	30+	15 24	10 08	11 14	40	35	34
30	Bullet	5 Hours	Sacrificed	1+	10+	6 17	6 82	8 16	22	22	24
55	Weight	4 Minutes	Sacrificed	2+	15+						
56	Weight	4 Minutes	Sacrificed	1+	10+						
57	Weight	24 Hours	Sacrificed	2+	20+				42	12	42
58	Weight	72 Hours	Sacrificed	3+	05+	11 47	5 16	11 94	38	39	36
112	Weight	4½ Hours	Sacrificed	1+	05+	11 01	11 28	11 16	37	38	37

Results—Table I shows the results of the 21 experiments in this series. The type of injury and the subsequent pathological picture were so similar with the two methods used in producing thoracic trauma that they are considered together without distinction.

Examination of Table I reveals the following facts:

1. Traumatic wet lung was produced routinely with the methods employed.
2. The amount of pulmonary fluid produced in each experiment varied directly with the degree of trauma.
3. The pulmonary fluid appeared very rapidly after thoracic trauma, was still present in proportion to the trauma inflicted at 24 hours, and had largely disappeared at 72 hours.

The microscopic pathologic picture of traumatic wet lung as it was produced in these experiments is as follows:

1. Alveolar rupture with extravasation of blood into the air spaces as previously described by one of the authors (R A D)⁴ and compared by him to blast effects obtained experimentally in water⁶ and air^{7, 8, 9}.
2. The presence of edema fluid characterized microscopically by dilated extravascular and lymphatic spaces and the presence of this fluid within the alveoli and bronchioles.

Grossly there was hemorrhagic consolidation of the directly traumatized lobes varying from slight to the consistency of liver. Often there was hemorrhage in the posterior portion of the opposite (left) lung, especially in the more severely injured animals. Frothy blood-tinged fluid exuded from the cut ends of the bronchi with gentle pressure. It was often present in the trachea. It was present in the greatest amounts in those lobes containing the most hemorrhage. The direct impact was usually over the lower lobes. Consequently, they were ordinarily the most severely involved. However, lobes exhibiting no gross evidence of trauma usually contained fluid, frequently in considerable amounts. The distribution of fluid in those areas of both lungs which did not appear to be traumatized was patchy and irregular, however.

Bleeding into the pleural cavity occurred in a few animals in small amounts. Three animals died of hemorrhage from lacerated wounds of the liver (Nos 13, 16, 19). Small hepatic lacerations were observed frequently.

Table I reveals that arterial oxygen saturation in animals which received severe trauma, sustained a drop which was out of proportion to the fall in hematocrit. A subsequent rise was then noted, even in the face of large accumulations of pulmonary fluid. There was little change in the oxygen saturation following slight trauma. The changes in the hematocrit were irregular. There was an initial drop in seven of 12 experiments. This was followed by a return to the pre-experiment level or above in three of the seven. There was a persistent depression in the remaining four, in all of which severe trauma had been inflicted.

II THE EFFECT OF INFUSION OF ISOTONIC SODIUM CHLORIDE ON THE "TRAUMATIC WET LUNG"

Methods—Eighteen mongrel dogs were anesthetized with intravenous sodium pentobarbital in doses of 30 milligrams per kilogram of body weight

This series of experiments is divided into two groups

In 11 experiments trauma was produced with the falling weight as in Series I. The average degree of trauma was, however, less than in Series I (Table II). Intravenous infusions of isotonic sodium chloride solution were then begun. They were administered from an infusion flask of one liter through rubber tubing and a glass cannula tied in the left femoral vein. The fluid was at room temperature in all experiments. The amounts of saline infused and the rates of infusion were varied. In experiments 59 and 60 small infusions were given before trauma was produced.

Seven animals were administered infusions of sodium chloride in exactly the same manner but were not subjected to trauma.

In nine of this series of experiments arterial blood samples were obtained for the determination of the arterial oxygen saturation and the hematocrit. The first sample was drawn after anesthesia was induced, the second sample shortly before termination of the infusion.

Venous pressure was recorded continuously in ten of the experiments. The measurements were made with a U-tube mercury manometer connected throughout the experiment into the right femoral vein, through rubber tubing, a 2 cc syringe and an 18-gauge needle. The fluid used in the system was isotonic sodium chloride.

The arterial blood pressure and the pulse were recorded in eight of the experiments. The blood pressure was obtained at intervals throughout the experiment from the exposed right femoral artery with a 20-gauge needle and U-tube mercury manometer. The pulse was obtained at intervals by direct count from the right femoral artery. Only the initial and the final values are recorded in Table II.

The animals were sacrificed with large intravenous doses of sodium pentobarbital with the exception of those expiring as a result of the infusions (Experiments 47 and 48). At autopsy the amount of pulmonary fluid and the degree of trauma inflicted were recorded as described for Series I. The degree of damage sustained by the liver, as determined by the extent of lacerations and the amount of blood lost into the abdominal cavity, was graded on the basis of 1, 2 or 3 and recorded in Table II because of the significant bearing it has on the results of this series of experiments.

Results—The results of this series of experiments are tabulated in Table II. The difficulty with which pulmonary edema may be produced in experimental animals by intravenous infusions^{10, 11, 12} is apparent in the control series of seven experiments. Isotonic sodium chloride injected intravenously at a rate of 10 cc per kilogram of body weight per minute to a total of 558.8 cc per kilogram produced only very slight evidence of pulmonary edema. This

is the equivalent of a little over 33 liters in 56 minutes for an average man (60 kilograms)

The infusion of the smaller amounts of isotonic saline resulted in an increase in the pulmonary fluid in six of 11 traumatized animals. There was in addition a difference in the distribution of the fluid as compared with traumatized animals receiving no infusions (Series I). It was found to be distributed uniformly throughout both lungs, whereas, in Series I there was a patchy distribution of fluid with localization of the severest grades of edema in the directly traumatized lobes.

The quantitative differences in the amount of pulmonary fluid in Series I and in the traumatized animals in Series II are not adequately described by figures. Comparable thoracic trauma resulted in small amounts of pulmonary fluid in Series I. Intravenous infusions of isotonic saline in amounts and at rates of injection which routinely are associated with no edema in normal animals produced diffuse collections of pulmonary fluid in six of the 11 traumatized animals of Series II. It was present in such amounts that it exuded from the cut ends of the bronchi for a matter of minutes with only the intrinsic pressure of the lung. These lungs tended to maintain their expanded shapes with a jelly-like consistency. In the remaining five experiments smaller amounts of pulmonary fluid were found at autopsy for reasons given in detail below.

The accumulation of fluid was less marked in three animals of this series which received severe thoracic trauma (Nos. 52, 59, 87). Two of these animals (52 and 59) sustained lacerations of the liver which allowed considerable quantities of blood to escape into the abdominal cavity. Another (animal 87) sustained a severe laceration of the right upper lobe which extended through its entire thickness with the escape of considerable quantities of blood into both pleural cavities. Luisada¹⁴ has commented on the prevention of pulmonary edema by simultaneous bleeding in animals receiving rapid intracarotid infusions. Two other animals (89 and 114) sustained very slight thoracic trauma. Their lungs also contained very little fluid. The extent of pulmonary edema which followed saline infusion was therefore proportional to the extent of trauma to the lungs.

The changes in the peripheral vascular dynamics and the hematocrit which we have noted in these experiments have been essentially the same as those described by other investigators studying intravenous infusions^{10, 11, 16, 17, 18, 19}. The arterial blood pressure increased initially then steadily declined to below pre-infusion levels. The pulse was uniformly fast following pentobarbital anesthesia and showed an inconstant rise with infusion. The venous pressure rose steadily. Hemodilution occurred routinely.

The venous pressures, the arterial blood pressures, the pulse rates and the hematocrits for the two groups are not significantly different. The final values for arterial oxygen saturation relative to the hematocrit are somewhat lower

TABLE II—The Effects of Venous Infusions of Isotonic Saline Upon the Normal and the Traumatized Lung

Animal No	Rate of Infusion cc/kg/Min	Amount of Fluid Infused per Kilo Body Wt	Cause of Death	Degree of Liver Damage	Degree of Trauma	Amount of Pulmonary Fluid	Venous Pressure Mm Hg	Arterial Blood Pressure		Pulse Rate		Arterial Oxygen Saturation (Vol's %)		Hematocrit (packed cell volume)	
								1	2	1	2	1	2	1	2
47	4.9	102.1	Expt			0	4-24								
48	10	558.8	Expt			1.5+	4-56					14.34	1.14	37	18
61	6.9	212.7	Sac			0	0-16					15.35	10.06	39	25
62	11.4	250	Sac			0	2-23					14.69	7.42	14	20
85	9.5	304.3	Sac			0									
88	9.6	308.1	Sac			0		112	118	137	137				
91	10.6	337.6	Sac			1.0+		170	128	160	124				
51	7.3	300.7	Sac	0	2+	4.0+	2-16	154	130	190	170	15.12	8.66	40	24
52	6.1	141.4	Sac	3+	2+	1.0+	2-10					18.53	7.91	18	23
53	7.6	229	Sac	0	3+	4.0+	2-20					19.65	9.86	16	27
54	8.1	138	Sac	0	2+	4.0+	2-20					15.28	5.58	46	26
59	11	131.6	Sac	2+	2+	1.5+	0-10-0							11	39
60	12.5	125	Sac	0	2+	3.0+	2-12-2					8.80	4.47	28	27
87	11.5	241	Sac	0	4+	2.5+		128	80	160	161				
89	10	200	Sac	0	1+	2.0+		106	98	160	176				
93	7.6	228.3	Sac	0	2+	1.0+		122	108	121	256				
113	6.5	225.3	Sac	0	2+	4.0+		111	132	186	150				
11	46.6	198.4	Sac	0	1+	0.5+		140	152	118	170				

in the traumatized animals than the control group. This can be explained on the basis of the increase in pulmonary fluid in the traumatized group.

The hearts of the animals in these experiments were found to be slightly but uniformly dilated. This has been noted by other observers studying massive infusions^{13, 18}. An exception occurred in the instance of experiment 47 in which the animal expired after receiving a relatively small amount of saline. This animal's heart was markedly dilated and there was no pulmonary edema.

Diarrhea occasionally occurred during the course of the infusions. Buccal and nasal secretions often became excessive. At autopsy all hollow abdominal organs were distended with fluid. Ascites was present in varying amounts. These findings are essentially as described in other observations on intra-venous infusions^{10, 18}.

III THE EFFECT OF ANOXIA ON THE "TRAUMATIC WET LUNG"

Methods—Seventeen mongrel dogs were anesthetized slowly with intra-venous sodium pentobarbital in doses sufficient to produce only the lighter planes of anesthesia.

The animals were connected to a continuous spirometer circuit by means of a tight fitting rubber mask with an inflated cuff. A 100-liter bell spirometer served as the reservoir. Mercury-seal valves were used in the circuit. A soda-lime canister removed carbon dioxide. All connections were of rubber tubing of large size.

The amount of oxygen in the inspired air was lowered initially by mixing nitrogen with room air in the spirometer. In five experiments the per cent of oxygen was kept at approximately a constant level by slowly adding tank oxygen to the spirometer air. Single average values for the per cent of oxygen are recorded in those experiments (Table III). In the remaining 12 experiments no attempt was made to replace the oxygen utilized by the animal. Two values are recorded for the per cent of oxygen. These represent the initial and final values.

Determinations of oxygen in the mixtures were made on 10 cc samples of gas withdrawn from the circuit through small rubber tubing. The determinations were made in a small modified Haldane apparatus. Oxygen was removed from the samples by repeated contact with pyrogallol over a wide surface area. The values reported represent the average of several samples. Repeated tests on room air revealed the accuracy of the method to be within a fraction of one per cent.

Arterial blood samples were obtained for the determination of arterial oxygen saturation and hematocrit in six experiments of this group. The first sample was drawn after anesthesia was induced, the second sample during the course of the experiment as indicated in Table III.

In addition to the procedures outlined above, eight of the animals were given infusions of isotonic sodium chloride solution through the left femoral vein. The rates of infusion and the amounts of saline administered are

recorded in Table III. The venous pressure was recorded continuously in five of the eight experiments by means of a mercury manometer connected to the right femoral vein. The initial figure recorded in Table III refers to the venous pressure before the experimental procedure was begun. The second figure indicates the venous pressure shortly before the death of the animals.

All of the 17 experiments in this series resulted in the death of the animals. At autopsy the thoracic and the abdominal organs were examined.

Results—The data from this series of experiments are tabulated in Table III. Intravenous infusions of isotonic sodium chloride decreased the survival time of eight hypoxic animals by more than 50 per cent as compared with the nine hypoxic animals receiving no fluid.

At autopsy the lungs of those animals expiring as the result of hypoxia alone were moderately congested in appearance, but exhibited no pulmonary fluid. The hearts were of normal size. On the other hand, the lungs of five of the eight animals expiring as the result of hypoxia plus intravenous infusions exhibited severe congestion and large amounts of fluid. The appearance of these lungs was comparable to that described in Series II for traumatized animals receiving intravenous infusions. Moderate cardiac dilatation was present.

The average per cent of oxygen in the inspired air was 13.1 per cent for those animals receiving infusions as compared to 11.4 per cent for those which received none. The average rates of infusion and total amounts of fluid injected per kilogram are considerably below those for control animals of Series II (Table II) which received infusions but breathed room air.

In three experiments the animals died after relatively small infusions of saline (experiments 36, 37 and 41). At autopsy there was considerable cardiac dilatation, but no pulmonary fluid. This picture in animals receiving intravenous infusions has been noted previously.

Examination of the values for arterial oxygen saturation reveals little difference between the two groups in this series of experiments, in spite of the large amounts of fluid observed in the lungs of five of the eight hypoxic animals receiving infusions. Determinations of the pressure changes in the rubber mask during respiration revealed changes no greater than one centimeter of water. Increasing dyspnea terminating in respiratory failure was noted in nearly all of these experiments. The changes in the venous pressure and the hematocrit in these experiments were similar to those observed with infusions in Series II.

DISCUSSION

"Traumatic wet lung" has been reproduced experimentally in mongrel dogs by both blunt trauma and tangential bullet wounds of the thoracic cage (Table I). The pathologic picture has been found to consist of

1. The extravasation of blood in the lung
2. The transudation of fluid into the interstitial spaces and the alveoli and bronchi

"WET LUNG"

TABLE III—The Effects of Hypoxia and of Intravenous Saline Infusions Upon the Lung

Animal	Per cent Oxygen in Inspired Air	Rate of Infusion cc/Kg /min	Amount of Fluid Infused per Kilo Body Wt	Survival Time in Minutes	Amount of Pulmonary Fluid	Venous Pressure mm Hg	Arterial Oxygen Saturation (Vol's %)		Hematocrit (packed cell volume)	Point in Expt at Which Blood Sample No 2 was Obtained
							1	2	1	2
30	12			150	0					
31	11-7			90	0					
32	10-7			60	0					
33	11			390	0					
34	12			180	0					
35	17-12			150	0					
38	14-10			120	0					
49	16-8			90	0					
50	16-8			135	0					
36	11		70	40	0		11 74	3 71		55 Minutes
37	13		75	50	0		11 20	3 75		55 Minutes
39	11-2	5	348 5	25	40+					
41	14-12	8 7	20 1	45	30+	8-14				
12	11-12	2 0	86	60	40+	8-20	13 84	2 67	37	34
11	14-10	3 3	148 5	15	40+	2-24	12 33	3 50	45	40
15	16-15	7 3	110	55	40+	4-24	11 59	0 80	33	26
16	16-11	6 7	280 5		40+	0-34	10 79	5 08	41	24
										44 Minutes In Extremis 35 Minutes Venous Pr 14 12 Minutes In Extremis 31 Minutes Venous Pr 16

The greatest degrees of pulmonary wetness were found in the areas of greatest hemorrhage in the traumatized lungs. However, fluid was often present in significant amounts in grossly untraumatized areas of the lungs. The total amount of fluid in the air passages varied directly with the degree of trauma inflicted.

Intravenous infusions of isotonic sodium chloride in amounts and at rates of injection which have little effect on the lungs of normal animals intensified the "wetness" of the slightly traumatized lung (Table II). Generalized pulmonary edema resulted. The difficulty with which pulmonary edema may be produced by intravenous infusions in the normal animal^{10, 11, 12} has been substantiated in our control experiments (Table II).

Drinker^{20, 21} has stressed the role of anoxia in the development of pulmonary edema. Asphyxia is known to result in a marked increase in capillary permeability.²² We have demonstrated pulmonary edema in hypoxic animals receiving infusions of isotonic sodium chloride (Table III). It was comparable to that observed in traumatized animals receiving similar infusions. Wet lungs could not be produced by the breathing of low concentrations of oxygen alone, however.

There is the possibility that severe grades of anoxia may exist in hemorrhagic areas of the traumatized lung on the basis of the blocking of air passages with blood and serum. Examination of the changes in arterial oxygen saturation in Series I reveals, however, that after an initial depression the saturation increased, even in the face of considerable "pulmonary wetness." Similarly, in Series II the depressions in arterial oxygen saturation were of approximately the same magnitude for the control animals with no pulmonary edema and the experimental animals with severe edema. Therefore, we feel that anoxia will not suffice to explain the wetness in grossly untraumatized areas of the lung following thoracic trauma.

There is an alternative explanation for the occurrence of pulmonary edema in areas of pulmonary hemorrhage. Harper and Tait¹ have called attention to the irritating effects of dispersed blood on the pulmonary tissue with the resulting transudation, and secretion of fluid. This cannot explain the formation of edema fluid, however, in those areas of the lungs in which no evidence of trauma was found.

Inspiratory resistance^{23, 14} and dyspnea²¹ are known to contribute to the formation of pulmonary transudates. Neither was present to a significant extent in our experiments on traumatized animals. On the other hand, increasing dyspnea occurred in all the experiments on hypoxic animals and may have played a part in the development of pulmonary edema following the infusion of saline.

There are changes which result from intravenous infusions which are important factors in pulmonary transudation. The pulmonary venous pressure has been found to increase^{10, 17, 18}. It has been said to rise more rapidly and to greater heights than the peripheral venous pressure.¹⁸ The increased peri-

peripheral venous pressure which developed in our experiments would indicate considerably elevated pressures within the pulmonary veins. Hemodilution occurs routinely^{10, 16, 11, 19} as reflected in decreasing hematocrits in our experiments. These changes undoubtedly contributed to the intensification of the pulmonary edema which we observed in traumatized and hypoxic animals receiving infusions of isotonic saline. They are, however, similar for both the control and the experimental animals.

The occurrence of generalized wet lung following localized pulmonary trauma cannot be completely explained on the basis of the data obtained in the experiments reported in this paper.

SUMMARY

1 "Traumatic wet lung" has been produced experimentally in mongrel dogs by blunt trauma and tangential bullet wounds of the thoracic cage.

2 Infusions of isotonic sodium chloride in amounts which have little effect on the lungs of normal animals have been found to intensify the pulmonary wetness which follows experimental thoracic trauma.

3 "Wet lung" has also been produced in dogs breathing low concentrations of oxygen by the infusion of isotonic sodium chloride solution but was not produced by hypoxia alone.

4 Studies of the arterial oxygen saturations, hematocrits, peripheral venous pressures, peripheral arterial blood pressures and the pulse rates in these experiments have not revealed variations of enough significance to explain the occurrence of generalized wet lung associated with localized areas of pulmonary injury.

II NEUROGENIC FACTOR

WILLIAM R. CATE, JR., M.D., AND ROLLIN A. DANIEL, JR., M.D.

In Part I of this paper we described the experimental production of traumatic wet lung in dogs. Intravenous infusions of isotonic sodium chloride solution were found to intensify the pulmonary wetness which follows thoracic trauma. The result was a generalized collection of pulmonary fluid. The outpouring of fluid was just as intense in areas of the lung fields in which there was no demonstrable evidence of pulmonary damage as in the lobes in which there was gross evidence of trauma. We were unable to explain these findings on the basis of the data which we had obtained.

The cause of acute pulmonary edema has been the subject of controversy for many years. Welch⁴¹ believed that left ventricular failure causes the syndrome. There is a considerable body of literature concerning the occurrence clinically of pulmonary edema accompanying disturbances in the central nervous system^{24, 25}. This picture, in the absence of heart disease, has not been satisfactorily explained. It has been suggested, by numerous observers, that pulmonary edema is dependent in certain instances upon reflex changes affecting the pulmonary vessels. Recently Luisada^{14, 27} and Farber^{19, 26, 28} have arrived at this conclusion as the result of animal experimentation. The latter

believes that the pulmonary edema which occurs in the rabbit and guinea pig following bilateral cervical vagotomy is similar to that which occurs in man following lesions of the central nervous system. He believes it is produced by an alteration in the vasomotor control of the pulmonary vessels, and terms the syndrome "neuropathic pulmonary edema."

More recently, Reichsman²⁰ has reviewed the subject of pulmonary edema which follows bilateral cervical vagotomy in experimental animals and has performed a large number of well controlled experiments upon rats. He concludes that the important factor in the pulmonary edema produced in this manner is inspiratory obstruction.

Luisada and Sarnoff¹⁴ performed unilateral stellate ganglionectomy upon three dogs and bilateral stellate ganglionectomy upon one dog. They believed that this procedure offered some protection against pulmonary edema produced by the rapid intracardiac infusion of large amounts of isotonic saline solution.

Henneman²⁰ has recently reviewed the literature on the subject of acute pulmonary edema.

We have conducted a number of experiments designed to determine the effect of unilateral and bilateral stellate ganglionectomy and dorsal sympathectomy upon experimental wet lung, particularly as produced by trauma and the intravenous infusion of saline.

METHODS

Mongrel dogs of various weights and undetermined ages were used in all experiments. All animals were anesthetized with sodium pentobarbital, 30 milligrams per kilogram of body weight, administered intravenously.

Two methods of producing "wet lung" were used.

- 1 Thoracic trauma, produced by a falling weight, followed by the intravenous infusion of isotonic sodium chloride solution as was described in our previous paper.

- 2 Bilateral cervical vagotomy followed by the intravenous infusion of isotonic saline as was described by Farber in the rabbit.¹⁹

Sympathectomy was performed in all animals under aseptic conditions. An antero-lateral incision was made through the second, third or fourth intercostal space. The stellate ganglion and the second, third and fourth thoracic ganglia were removed intact with the chain. The lung was re-inflated and the wound of the chest wall was closed in layers with interrupted fine silk sutures. 50,000 units of penicillin in solution were placed in the pleural cavity of most of these animals before closure of the wound. In the early experiments in which bilateral sympathectomy was performed, the operation was carried out in stages, five to seven days elapsing between operations. In the later experiments bilateral sympathectomy was performed in a single operation through separate incisions.

In most of the experiments a period of one week or more elapsed between

the time of sympathectomy and the experimental procedure. This was thought to be desirable in order to eliminate factors caused by operative trauma and altered pulmonary dynamics which might predispose to pulmonary edema.

At autopsy light adhesions between the superior lobes and the line of incision in the parietal pleura were found in some animals. In most animals no adhesions or fluid were present and there was no other evidence of previous pulmonary damage.

All unilateral sympathectomies were performed on the right side. The term "dorsal sympathectomy" will be used throughout this paper to indicate the operation described.

The arterial blood pressure was obtained at intervals throughout all experiments from the exposed right femoral artery, with a U-tube mercury manometer and a 20-gauge needle. The fluid used in the system was isotonic saline. The pulse rate was also recorded at frequent intervals throughout the experiments.

All infusions consisted of isotonic sodium chloride solution administered through glass canulae into the femoral vein.

RESULTS

In our previous paper we called attention to the association in a few animals of cardio-vascular failure during infusion with the absence of pulmonary edema. We have omitted the experiments of this paper in which such an association was noted. They comprise ten or 16.7 per cent of the total.

Five of 11 animals with bilateral dorsal sympathectomy expired during infusion (45.4 per cent). Only two of 12 animals with unilateral dorsal sympathectomy succumbed (16.7 per cent). The greater mortality rate among the dogs with bilateral sympathectomy may have been caused by postoperative debilitation of the animals.

A. The Effects of Trauma and of Infusion of Isotonic Saline Upon the Lungs of Animals Previously Subjected to Dorsal Sympathectomy

Nine dogs in which previous dorsal sympathectomy had been performed were subjected to blunt thoracic trauma followed, within ten minutes, by intravenous infusions of isotonic sodium chloride solution. The results are recorded in Table I.

In five animals sympathectomy was bilateral and in four unilateral. The longest time interval between operation and the experimental procedure was 21 days, the shortest seven days.

Only one animal in the entire group of nine developed diffuse pulmonary edema. Bilateral sympathectomy had been performed seven days prior to the experiment (Dog No. 228b).

These results are to be compared with the collection of large amounts of pulmonary fluid in six of 11 animals similarly treated but without the benefit of a dorsal sympathectomy (Series II of our previous paper). The difference is even more apparent when we recall that three of the five animals of the latter group not developing excessive amounts of pulmonary fluid had

TABLE I—*The Effect of Dorsal Sympathectomy Upon Wet Lung Produced by Trauma and Intravenous Saline Infusions*

Animal No	Dorsal Sympathectomy	Time Between Sympathectomy and the Expt	Degree of Trauma	Rate of Infusion cc/kg/min	Amount of Saline Infused per Kg Body Wt	Cause of Death	Amount of Pulmonary Fluid	Arterial Blood Pressure			
								Mm Hg *		Pulse Rate	
								1	2	1	2
228	Bilateral	17 Days	3+	8.0	252.6	Sac	1+	104	84	102	98
106	Bilateral	7 Days	2+	6.5	254.2	Sac	0.5+	106	86	126	126
228b	Bilateral	7 Days	4+	13.4	227.3	Died during infus	4+	124	76	116	110
3c	Bilateral	9 Days	3+	17.9	268	Sac	1+	126	120	144	78
106b	Unilateral	12 Days	3+	8.3	266	Sac	0.5+	128	112	112	112
1e	Unilateral	21 Days	3+	6.9	254.2	Sac	1+	120	102	126	130
5b	Unilateral	8 Days	2+	9.3	277.8	Sac	0.5+	124	130	136	200
3b	Bilateral	12 Days	4+	9.0	266.7	Sac	1+	120	106	170	176
303	Unilateral	7 Days	3+	7.5	240.9	Sac	1+	104	102	112	128

* Reading No 1 was taken just before the experimental procedure (trauma) was started
Reading No 2 was taken just before the death of the animal

TABLE II—*The Occurrence of Wet Lung in the Dog Following Bilateral Cervical Vagotomy and Intravenous Saline Infusions*

Animal No	Time Between Vagotomy and Infusion	Rate of Infusion cc/kg/Min	Amount of Saline Infused Per Kg Body Weight	Cause of Death	Amount of Pulmonary Fluid	Arterial Blood Pressure*		Pulse Rate*	
						Mm	Hg		
						1	2	1	2
73	0	8.9	257.1	Sacrificed	2+	131	90	160	136
74	11 Minutes	6.9	255.2	Sacrificed	0	156	110	149	112
75	33 Minutes	8.1	251.7	Sacrificed	4+	140	120	170	141
76	39 Minutes	11.4	250.0	Sacrificed	1+	148	90	145	125
77	47 Minutes	11.1	222.2	Sacrificed	4+	156	81	165	120
84	35 Minutes	8.9	160.6	Sacrificed	1+	161	111	180	120
91	38 Minutes	7.7	230.8	Sacrificed	1+	196	123	190	168
115	5 Minutes	6.2	272.2	Sacrificed	0				
116	25 Minutes	7.2	103.7	Sacrificed	1+				
117	26 Minutes	6.6	277.1	Sacrificed	1+				
118	16 Minutes	6.5	333.3	Sacrificed	0				
119	18 Minutes	6.4	268.0	Sacrificed	1+	150	121	170	126
120	26 Minutes	7.0	266.7	Sacrificed	0	132	132	152	141
121	51 Minutes	6.1	257.8	Sacrificed	0	121	120	148	122
122	183 Minutes	8.1	175.5	Sacrificed	0	121	136	190	170

* Reading No 1 was taken before beginning the experiment
Reading No 2 was taken just before the death of the animal

suffered major hemorrhage and that the remaining two received insignificant trauma. We know that protection is afforded against the development of pulmonary edema by simultaneous blood loss in animals receiving rapid intravenous infusions. None of the sympathectomized animals included in this series sustained similar hemorrhage.

No difference could be noted in the animals in which bilateral dorsal sympathectomy had been performed and those which had had unilateral (right) sympathectomy, with the exception of dog No. 228b. Autopsy examination of the lungs of animal No. 228b revealed large amounts of frothy blood-tinged fluid in all the bronchi. In the remaining eight animals small amounts of fluid were found only in those areas of the lung fields exhibiting evidence of trauma.

B. The Effect of Dorsal Sympathectomy on the Occurrence of Pulmonary Edema Following Bilateral Cervical Vagotomy

The controversy concerning the effect of bilateral cervical vagotomy in the rabbit, guinea pig and rat has been referred to above. Farber has used bilateral cervical vagotomy followed by intravenous infusions of isotonic saline as a method for the rapid production of pulmonary edema in the rabbit.¹⁹

We have repeated this procedure in 15 dogs. The results are recorded in Table II. In all of these experiments a large rubber tube was placed in the trachea to a level well below the larynx. We could note no evidence of respiratory obstruction in any of these animals. Most of them breathed more quietly than normal animals receiving similar infusions. A peculiar jerking type of respiration was occasionally noted with no correlation with the presence or absence of edema. A similar type of respiration was noted in other animals without vagotomy.

Wide-spread collections of frothy blood-tinged fluid developed in the lungs of eight animals. In six of the eight, the amounts of fluid were so great that considerable quantities were expelled from the tracheal tubes before the animals were sacrificed. In one (No. 73) there was a moderate diffuse pulmonary edema. In six animals the lungs remained dry and were normal in appearance at autopsy.

We felt in the early experiments that the time interval between vagotomy and infusion might be of importance. Five of the first seven animals developed wide-spread edema. The two not developing edema in large amounts (No. 73, 74) were infused much sooner after vagotomy than the remainder. However, there is no correlation between the time interval and the presence or absence of edema in the next eight experiments, in only three of which wet lung developed.

The procedure of bilateral cervical vagotomy plus isotonic saline infusions was also carried out in nine dogs with previous dorsal sympathectomy. These experiments are recorded in Table III. Bilateral sympathectomy had been performed in two animals and unilateral sympathectomy in seven.

Three animals developed a significant amount of pulmonary fluid (Nos 78, 79 and 145). In two of these animals the experimental procedure was begun within an hour after unilateral sympathectomy was performed (Nos 78 and 79). In the remaining seven experiments an interval of from five to 21 days elapsed between sympathectomy and the attempt to produce wet lung. Only one animal in the latter group developed wide-spread pulmonary edema.

Examination of Tables II and III reveals that there are no significant variations in the peripheral blood pressures or pulse rates, rates of infusion or total amounts of fluid infused which can be correlated with the presence or absence of edema in these animals, either with or without sympathectomy. However, the time interval between sympathectomy and the experimental procedure appeared to be significant.

C The Effect of Infusions of Isotonic Sodium Chloride Solution Within 45 Minutes After Unilateral Dorsal Sympathectomy

In the preceding experiments we have noted a decreased incidence of wet lungs in dogs with dorsal sympathectomy, either bilateral or unilateral, performed five to 21 days before the experimental procedures. This was not true in two instances (Nos 78 and 79, Table III) in which unilateral dorsal sympathectomy was performed within 60 minutes of the experimental procedure. Furthermore, pulmonary edema of slight to moderate severity was observed at the autopsy of three of ten animals expiring within 24 hours after dorsal sympathectomy.

The group of experiments summarized in Table IV includes seven mongrel dogs. Infusions of isotonic sodium chloride were administered to five of the animals within 45 minutes after unilateral dorsal sympathectomy. Pulmonary edema developed in three of the five, the quantity of pulmonary fluid varying from slight to excessive. Two more animals were treated in the same manner with the exception that the sympathetic chain was left undisturbed. These animals were given large amounts of saline. They developed no pulmonary edema.

DISCUSSION

"Traumatic wet lung" has been demonstrated experimentally in dogs (See Part I). Anoxia and the irritating effects of dispersed blood were offered as explanations for the occurrence of edema in areas of the lungs which exhibited evidences of trauma. We were unable to explain the frequent occurrence of pulmonary wetness in grossly untraumatized areas of the lung fields or its diffuse distribution when infusions of isotonic sodium chloride were administered following thoracic trauma.

Rapid improvement often followed the use of intercostal or paravertebral nerve block in the treatment of traumatic wet lung among the wounded of World War II. Brewer and others² have suggested that reflexes responsible for the syndrome were blocked by this procedure. The beneficial effects of nerve block are certainly due in part to the relief of pain.

TABLE III—The Effect of Dorsal Sympathectomy Upon Wet Lung Produced by Vagotomy and Saline Infusions

Animal No	Sympathectomy	Time Between Sympathectomy and Expt	Time Between Vagotomy and Infusion	Rate of Infusion (cc/kg/Min)	Amount of Saline Infused per Kg Body Wt		Cause of Death	Amount of Pulmonary Fluid	Arterial Blood* Pressure		Pulse Rate*	
					Kg	Body Wt			Mm	Hg	1	2
78	Unilateral	17 Minutes	32 Minutes	7.4	237.2		Sac	3+	180	140	152	125
79	Unilateral	60 Minutes	12 Minutes	11.4	135.4		Expt	3+	92	72	106	82
146	Unilateral	18 Days	43 Minutes	8.6	300.0		Sac	4+	132	138	114	120
X-42	Unilateral	14 Days	39 Minutes	8.9	222.2		Sac	0	164	160	120	126
219	Unilateral	8 Days	41 Minutes	9.9	257.4		Sac	0	138	108	118	118
X-15	Unilateral	7 Days	36 Minutes	10.2	265.5		Sac	1+	106	94	134	114
306	Unilateral	21 Days	61 Minutes	6.6	282.3		Sac	0	106	104	120	126
7b	Bilateral	8 Days	23 Minutes	10.6	264.4		Sac	0	132	118	120	116
67b	Bilateral	5 Days	53 Minutes	16.8	319.2		Sac	0.5+	138	114	106	109

* Reading No 1 was taken before beginning the experiment
Reading No 2 was taken just before the death of the animal

TABLE IV—The Effect of Intravenous Infusions of Saline Immediately Following Dorsal Sympathectomy

Animal No	Operation	Rate of Infusion cc/kg/Min	Amount of Saline Given Per Kg Body Weight	Cause of Death	Amount of Pulmonary Fluid	Arterial Blood Pressure*		Pulse Rate*	
						Mm	Hg	1	2
80	Sympathectomy	11.7	246.3	Sacrificed	3+	72	72	100	75
86	Sympathectomy	19.7	266	Sacrificed	4+	90	60	92	74
90	Sympathectomy	10.0	200	Sacrificed	0	110	88	164	164
92	Sympathectomy	8.5	213.6	Sacrificed	0	130	168	142	156
95	Sympathectomy	9.4	217.1	Sacrificed	2+	126	102	160	144
81	Thoracotomy	8.3	350.9	Sacrificed	0	144	92	151	136
83	Thoracotomy	12.1	277.7	Sacrificed	0	120	124	126	130

* Reading No 1 taken before infusion was begun
Reading No 2 taken just before the death of the animal

Detakats⁴³ has observed reflex broncho-constriction following experimental blunt trauma to the thoracic cage Burford and Burbank³ felt that broncho-constriction of similar origin might be of importance in traumatic wet lung

Pulmonary edema has been observed following central nervous system disturbances of many types in the absence of significant cardiac disease^{28, 24, 25} It has also been observed experimentally following bilateral cervical vagotomy

Farber^{19, 26, 28} using rabbits and guinea pigs reached the conclusion that the pulmonary edema which follows bilateral cervical vagotomy is due to reflex alterations in the pulmonary vessels Reichsman²³ working with rats concluded that inspiratory obstruction was the primary factor

The presence of a vasomotor control of the pulmonary vessels is a controversial subject, whereas the reactions of the bronchial musculature are well established^{40, 41} Daly³³ believes that vasoconstrictor fibers are distributed to the pulmonary and bronchial vessels through branches of the vagi as well as the sympathetic nerves in the dog Hamilton and his co-workers³² feel that the vasomotor control of the pulmonary arterioles is a feeble mechanism A consensus of opinion is that such a control does exist, but that it is of less importance than the systemic vasomotor mechanism⁴²

Karsnei³⁵ has described nerve fibrillae in the pulmonary artery of the dog Larsell³⁶ has described the innervation of the human pulmonary and bronchial arteries and capillaries which he states is apparently of post-ganglionic sympathetic fibers

The sympathetic supply to the lungs arises from T₁ to T₄ or T₅ and is distributed to the lungs through the inferior cervical and the corresponding dorsal ganglia³⁸ It is bilateral in distribution³⁹

In this paper we have reported a number of experiments on the effects of unilateral and bilateral dorsal sympathectomy Dorsal sympathectomy refers to the removal of the inferior cervical and the first four dorsal sympathetic ganglia with the intervening chain

Two methods of producing "wet lung" have been used,¹ Blunt thoracic trauma followed by infusions of isotonic sodium chloride as described in our previous paper² Bilateral cervical vagotomy followed by infusions of isotonic sodium chloride as described by Farber¹⁹

Whereas wet lung can be produced with regularity by blunt trauma to the thorax followed by intravenous saline infusions, significant wide-spread collections of pulmonary fluid developed in only one of nine animals subjected to the same procedure seven to 21 days after dorsal sympathectomy Bilateral sympathectomy had been performed in five of these animals, unilateral sympathectomy in four However, dorsal sympathectomy had no effect on the occurrence of edema in areas of the lungs which exhibited evidence of trauma

Bilateral cervical vagotomy followed by saline infusions did not produce wet lung with the same regularity as did trauma and saline infusions It

developed in nine of 15 animals. We could not predict in which animals edema would occur. On the other hand, generalized pulmonary edema occurred in only one of seven animals in which unilateral or bilateral dorsal sympathectomy had been performed five to 21 days prior to the same experimental procedure.

The time interval between the sympathectomy and the experimental procedure employed to produce generalized pulmonary edema was of no importance within the limits of five and 21 days. When the intravenous infusion of saline was begun soon after sympathectomy, however, the removal of the sympathetic chain appeared to have no influence upon the occurrence of wet lung.

The experiments reported in this paper were designed to determine the importance of the autonomic nervous system in wet lung, particularly as it is related to thoracic trauma. No attempt was made to study the specific changes in physiology which were operating other than observations on the peripheral arterial blood pressure and the pulse rate.

We believe that a reflex mechanism does exist which plays an important role in generalized wet lung which follows thoracic trauma. In the dog, the removal of a large portion of the sympathetic nerve supply to the lungs tends to prevent diffuse pulmonary edema produced by the methods which we have described. Whether these reflexes have their greatest effect upon the pulmonary blood vessels or the bronchi and bronchioles, we do not know.

SUMMARY

The effects on experimental "wet lung" of excision of large portions of the pulmonary sympathetic supply have been studied in the dog. The results of these experiments indicate that generalized wetness following local trauma to the thoracic cage and the lung is in part a reflex phenomenon.

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DISCUSSION—DR JAMES M MASON III, Birmingham, Alabama Doctor Daniel's paper was excellent I have nothing to add to his experimental work on the problem of "wet lung" From the practical standpoint, however, I wish to say a few words During the war we encountered wet lung very frequently in chest injuries and in other types of wounds We see it in civilian life in traumatic and elective surgical cases The simple procedure of intercostal nerve block with novocaine is very helpful When considerable fluid is being poured out into the bronchial tree, bronchoscopy or tracheal catheterization with suction will prove helpful In this condition the judicious use of the bronchoscope has saved many lives

FACIAL PARALYSIS SUPPORTED WITH AUTOGENOUS FASCIA LATA*

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PARALYSIS OF THE SEVENTH nerve presents one of the most difficult problems, and procedures in plastic surgery for such patients are considered when there is thought to be no chance of nerve recovery or of nerve operation. It also may be useful to support the face during a waiting period in the process of nerve recovery or of neuro-surgical work.

It is best to realize from the start that a rather crude substitution is about all that can be done. The finely kinetic actions of the muscles of the face, supplied by the seventh nerve, such as the gentle approximation of the eyelid to the globe—awake or asleep—and the delicate movements of emotional expression, hardly can be expected to be normally restored by the substitution of a few points of suspension with fascial loops or muscle flaps. And so—as in much of plastic surgery where missing parts have to be supplied—a substitution has to be made.

Most patients have been so distraught with their plight, but are so cooperative and appreciative that it is necessary to strive for the procedure which will produce the most effective substitution.

The use of fresh autogenous strips of fascia lata, continues to be one of the basic methods of support, although there are several other procedures for supporting the face with various degrees of efficacy being obtainable. These strips are anchored in the temporal (fifth nerve) muscle and fascia and looped down through the face in two or more levels. The bulk of the face is elevated to an overcorrected position and the loops are anchored securely. The utilization of the temporal muscle and its fascia and strips of fascia lata has been reported elsewhere,^{1,3} and at this time additional findings and points worthy of emphasis are recorded.

Time for operation, is important and paradoxically it is before much sagging of the face has occurred. It is usually not done in early childhood, but it probably could be done then. One boy we saw with double congenital paralysis seemed an ideal type to try to help, but so far the parents haven't agreed. This is such a striking deformity that almost any improvement would be acceptable. We have done patients after 40 years of paralysis but these are apt to be the most difficult because of the long standing soft tissue sag and redundancy. In these patients, the mouth and lip and nasal level can be elevated, but the excess tissue falls over like a tent or an awning. Heavy thick or edematous faces are not helped greatly by this procedure, that is if the face can't be pulled into a satisfactory position before operation, then the fascial strips can't be relied on to do it either.

* Read before the Southern Surgical Association at Hollywood Beach, Florida, December 9, 1947

Excision of excess skin, can be done, preferably before or after the fascial transplant operation. Wide undermining and tension is necessary, and it is usually thought best not to add this to the transplantation as there is the necessity of firm healing over the fascial loops in the temporal region. Suturing of the fascial loops is possibly best done with fine wire, though cotton or silk may suffice.

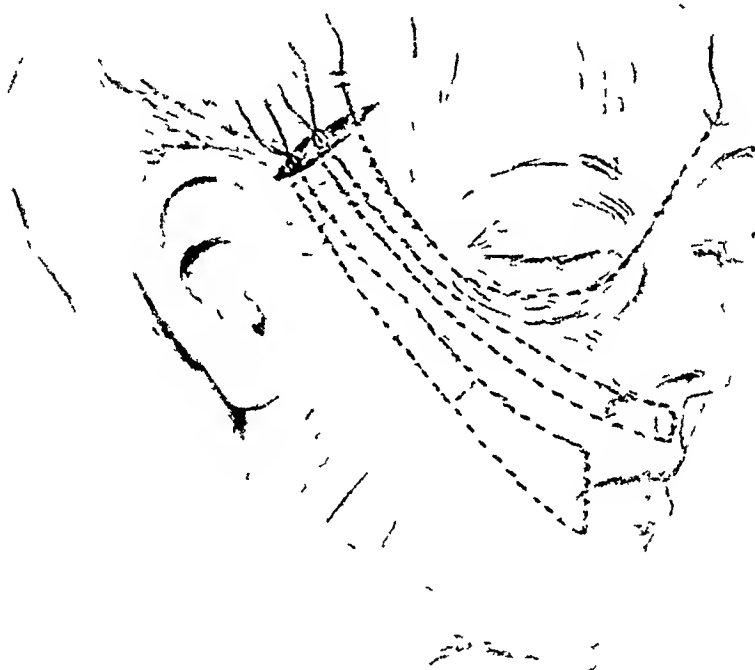


FIG 1—Shows course of fascial loops through face to upper lip, angle of mouth, and lower lip. These are anchored in the temporal muscle and fascia. The loop through the lower lid is anchored in the opposite frontalis region and in the temporal fascia, not in the temporal muscle.

Improvement in comfort of the eye is one of the main objectives. This is obtained by (1) the elevation of the tissues with the large loops in the face. Patients even may be able to close the eye from this element alone. (2) An external canthoplasty of 4-5 millimeters is usually productive of increased comfort and improved appearance. The extra sclera that nearly always shows up is hidden quite well by this procedure. The approximation of the lids is done along the tarsal border so that the lashes remain and there is not too much evidence of the partial closure, without close scrutiny. (3) A separate loop of fascia can be anchored in the temporal fascia on the outside, carried through

the lid, and fastened in the opposite frontalis muscle. This is a pretty fine adjustment to make in such a gross manner and it is not relied on if it is thought that the general elevation and the canthoplasty will suffice. The fascia is apt to form a little ridge as it goes across the side of the nose, but this is not too objectionable. (4) A flap of opposite frontalis fascia or muscle, or both, can be brought down and an attempt made to tighten the lid sag with it, or the flap may come from the temporal region. (5) The production of a Horner's syndrome is mentioned but has not been relied on by us. It would seem contraindicated if there was marked sagging of the brow. Closure of the eye is improved in most patients, and even though it is not complete in sleep, they nearly all have



FIG 2—A B Complete paralysis elevated with fascial loops. The eye can practically close from the 2 major loops alone. B, C, D and F are 6 mo. after A and E.

good Bell's signs (of rotating the eyeball up on closure), so that the cornea is rarely exposed. Some patients are able to keep the eye fairly well closed even in sleep.

A nasolabial fold is important for balance of the face—absence of it, and droop of the upper lip is perhaps the most noticeable feature of seventh nerve paralysis, when the face is in repose on the opposite side. It is important to try to reproduce a semblance of this fold and it comes in by adequate elevation of the angle of the mouth, at operation this area is so overcorrected that the face is distorted.

Movement of the paralyzed side is possible by pull of the temporal muscle but not too much is desirable because of its being noted too much on eating. But this movement is advantageous, and with a little effort many patients can substitute it for a little emotional expression. A smile can be simulated by the above action, and along with a nasolabial fold, these probably give the patient

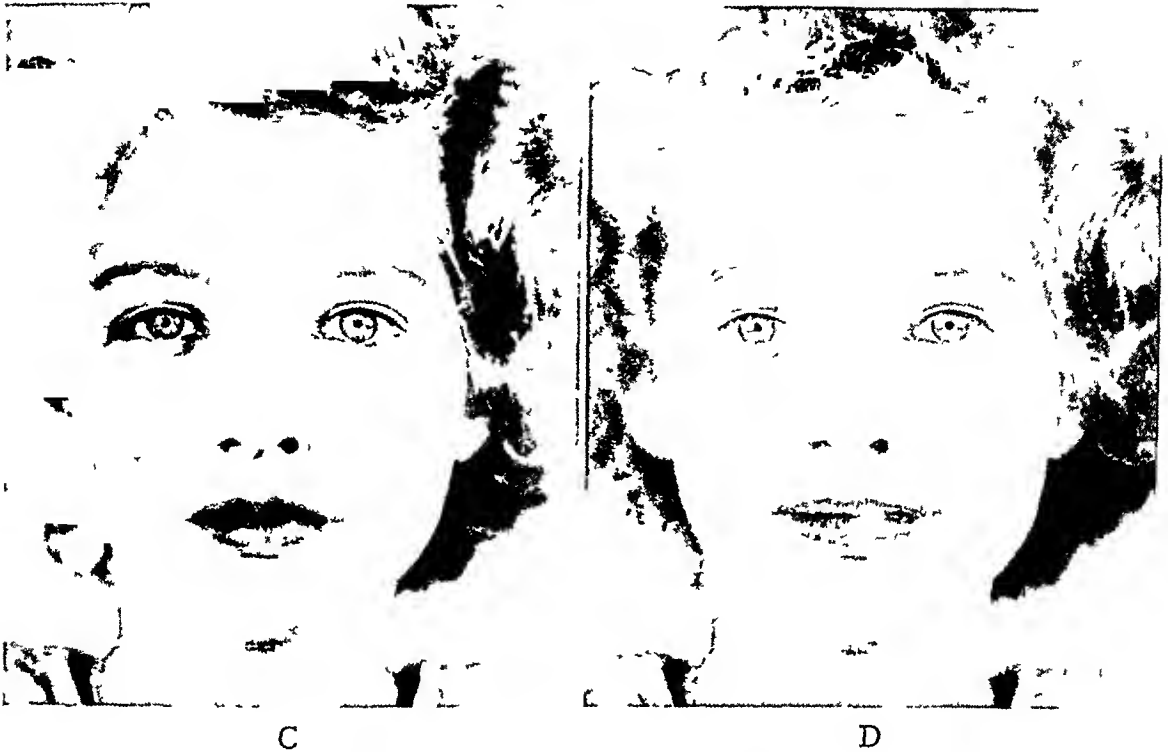


FIG 2 C D—If not much activity or emotion is expressed on the sound side the symmetry is close to normal

his most normal appearance. Improved eating is nearly always obtained by the supported cheek holding food better during mastication.

Training of the opposite normal side is very important, and the patient who can control the degree of his emotional expression in laughing and in conversation, even though he has to be a little glum, will help the surgical result materi-



FIG 2—E & F Six months after fascial transplantation. The profile is improved by the elevation of the fascial loops.

ally The training is usually easy and is carried out by the patient himself with the aid of mirror exercises

Partial facial paralysis may be improved by adding fascial support, but nothing should be done to interfere with any "tone" of the facial muscles that might be getting in through any nerve channel Even an unsuccessful nerve operation or anastomosis should not be taken down or interfered with if any "tone" at all is being supplied The grimaces that may result from anastomosis and the mass movements that may occur following nerve suture, may possibly be improved by fascial support, and training

The needles for threading the fascia through the face should be as simple as possible Complicated Reverdin or locking types are cumbersome and unnecessary The simple types shown here are rigid pieces of steel mounted on

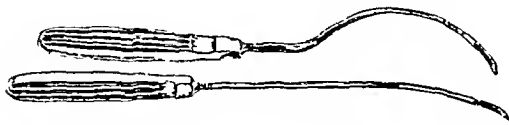


FIG 3—Simple needles, slotted at the point used for the long loops thru the face, and for the loop thru the eyelid

handles with slotted eyes in the pointed ends One is for the face loops and one to go around the eye—through the lid These were made originally for one of us by Dr Richard Douglas Saunders The heavy

facia needle to carry the loops through the temporal muscle can be improved by enlarging the eye with a file Pressure dressings using cotton mechanics waste are always relied on, and the face is supported with adhesive for two to three weeks

The drooped eyebrow can be improved by elevation and excision of tissue up in the hair line, or a separate loop of fascia may be tried, anchored high enough

Secondary Adjustments are done as necessary and include adjustment of the loops, and excision of excess skin above in the hair region Very rarely is any excision of skin done in the face, but in long-standing instances and where the face falls over the fascial strips like an awning, some adjustment may be necessary in the nasolabial region or close to the angle of the mouth

Complications are mainly as listed in adjustments, but as in all plastic surgery—infection is the main complication So much depends on the healing of these wounds and so slight an infection militates against a desired result that every effort should be taken to prevent contamination and infection

Results are far from what we would like for these patients, but as illustrated by the following they may be worth while Her eye can close, in repose she looks about normal, she has a slight smile, and by training to avoid over-action of the sound side, she gets by with many persons who see her, not realizing that her face is paralyzed

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PRESERVATION AND RESTORATION OF MANDIBULAR FUNCTION AND CONTOUR*

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MANDIBULAR FUNCTION AND CONTOUR are often jeopardized by operations, trauma or infection. Immediate measures for preservation of function may suffice or be supplemented with secondary repair.³

LIMITATION OF MOUTH OPENING

Trismus is a temporary inelasticity of the soft tissues between the jaws resulting from inflammation. Permanent fixation may be the result of several factors and may be classified as true or false ankylosis, depending upon whether or not the temporomandibular joints are involved. An accurate diagnosis of the cause is essential.

Surgery, trauma or infection in the neighborhood of the temporomandibular joints may result in either bony or fibrous obliteration of the joint (Figs 1 and 2). Frequently the causative trauma is extensive and in addition to joint obliteration the coronoid process may be anchored to the zygoma. In such conditions adequate resection of the joint area, including the coronoid process if necessary, will give relief. More dependence should be placed on the adequate removal of bone at the site of the resection than on the application of some substance between the resected ends. All bone-forming detritus must be removed.

This resection is commonly done from in front of the ear, reflecting the parotid gland and facial nerve forward and downward and elevating these structures outward from the bone. In certain simpler conditions it may be done from within the mouth. The most difficult ankylosis, represented by a broad, thick mass of bone and a short ramus, had best be approached from the neck, elevating all soft tissues, including the facial nerve and parotid gland, from the ramus of the mandible, beginning the resection on the ramus above the angle and working upward to include the condyle and coronoid process (Fig 1). Such a resection causes very little dysfunction except to diminish the power of the bite and does not disturb dental occlusion, as does removal of the body of the mandible.

False ankylosis often follows depletion of the soft tissues connecting the jaws. Loss of mucosa, the full thickness of the cheek, or the skin of the cheek, if in large amounts, will have this effect. The removal of superficial lesions of cheek mucosa may be followed immediately or later by replacement with split thickness skin grafts. Deeper losses may require replacement with a pedicle flap.

* Read before the Fifty-ninth Annual Session of the Southern Surgical Association, December 9-11, 1947, Hollywood, Florida

A

B



FIG 1—Ankylosis of 30 years' duration from infection in childhood A Note underdevelopment and asymmetry of mandible Previous operations done elsewhere had failed because of reformation of bone at the site of the resection Complete removal of the short, thickened ramus from angle up to the base of the skull on the affected side gave good mouth opening The normal joint, though not used for 30 years, rapidly regained function B Note improvement of contour by overlaying mandible with implants of cartilage

A

B



FIG 2—A Partial ankylosis and paralysis of lower branch of facial nerve, from infection in infancy B Correction of ankylosis by resection of temporomandibular joint by a direct approach from in front of the ear, resecting an adequate amount of bone to prevent re-ankylosis

Subsurface scarring in the region of scant clearance between the coronoid process and zygomatic arch may cause firm fixation in a closed position. Adequate resection of the coronoid process from within the mouth to release one point of scar anchorage will give relief. Depressed fractures of the zygomatic arch will produce impingement on the coronoid process, preventing mouth opening (Fig 3)



FIG 3—Illustrating one typical cause of limitation of mouth opening following fracture. A fragment of bone from the zygoma has been driven inward, impinging on the coronoid process, blocking its excursion. Removal of the coronoid process from within the mouth gave normal mouth opening.

SOFT TISSUE CONSIDERATIONS

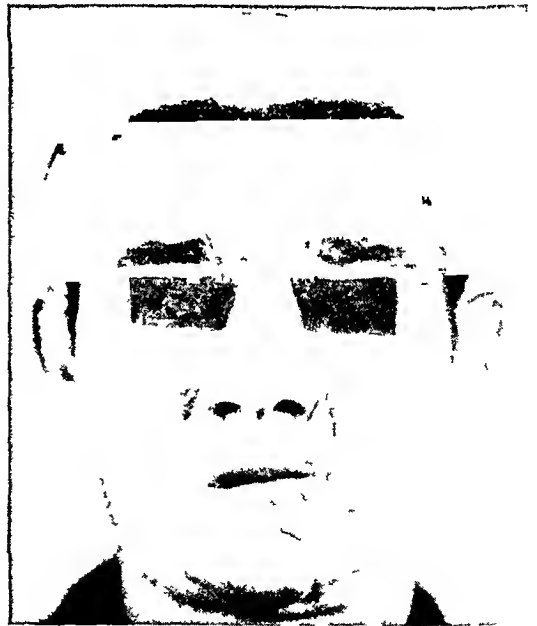
At the time of injury or resection all possible soft tissue must be preserved (Fig 4). In treating acute injuries of the face, debridement is not practiced to the extent often employed in wounds of other parts of the body. In operations for cancer large areas of soft tissues may be destroyed and

replaced later. Before a bone graft to the mandible is done, adequate covering for the graft must be present. If the quality or amount of tissue is

A



B



C

FIG 4—A. Extensive loss of soft tissue and bone of the symphysis region from gun shot wound. B. Result obtained at primary repair. All soft tissue possible was preserved. The remaining bone fragments were held in their proper relationship by interdental wiring. Note good contour of lower third of face as compared with narrowing from similar injury on patient shown in Fig 5. C. Result following use of pedicle flap to inside and outside of mouth and successful bone graft to mandible. Pedicle flap similar to that illustrated in Fig 6 was used.

A



B

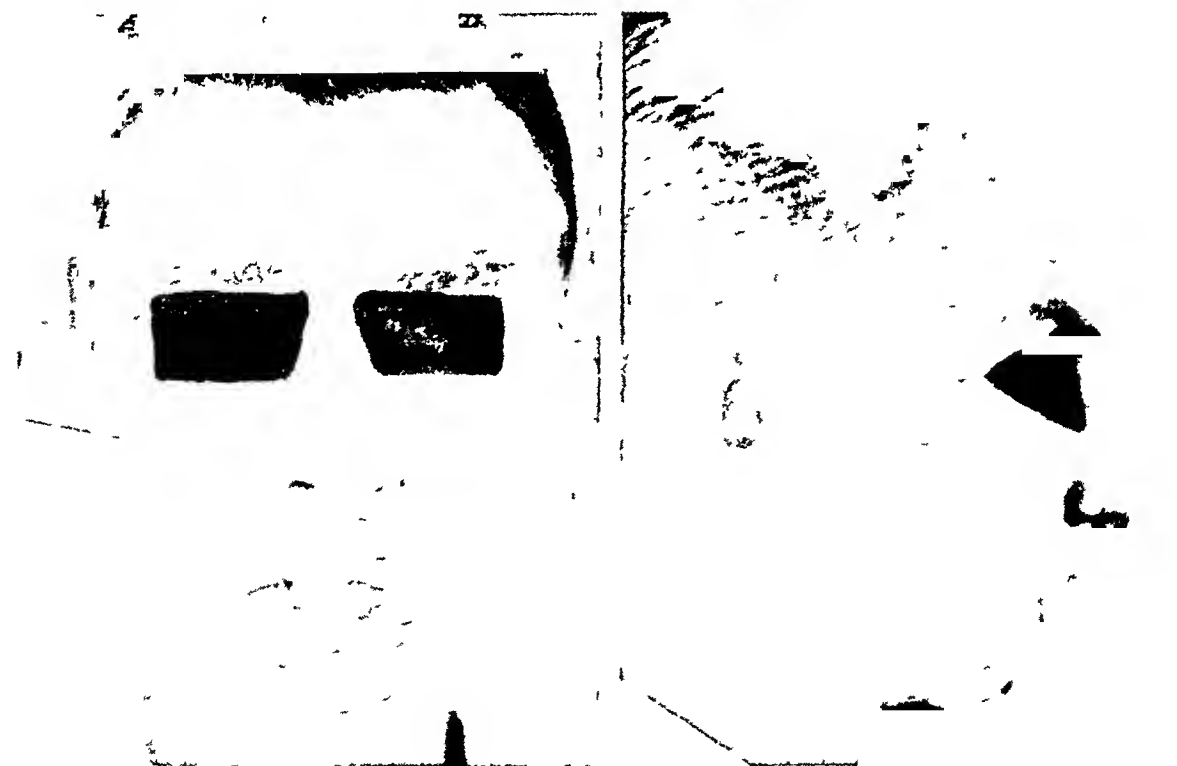


FIG 5—A Extreme soft tissue and bone loss from gun shot injury. Note narrowing of lower portion of face due to inward displacement of remaining bone fragments. B Restoration by means of added soft tissue (Fig 6) to give adequate covering for a bone graft and restoration of mandibular continuity by the use of two ribs extending from angle to angle, a double thickness of rib being used at the symphysis. Previous attempts at bone graft done elsewhere had failed because of inadequate soft tissue covering (*Surg, Gynec, & Obst*, 84: 870, 1947)

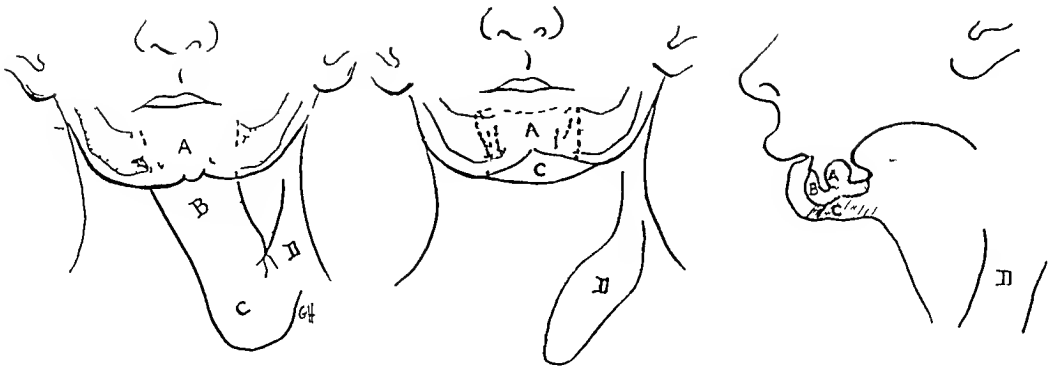


FIG 6—Diagram illustrating source and use of the pedicle flap for restoration of soft tissue loss in patient shown in Fig 5. The tip of this flap was let into the mouth through a submental incision to replace the constricting and inadequate scar tissue between the ends of the bone. The center portion of the flap was used to line the labial sulcus, the proximal portion supplied the external covering of the chin and submental area, and the base of the flap was returned to the neck. (*Surg, Gynec & Obst*, 84: 870, 1947)

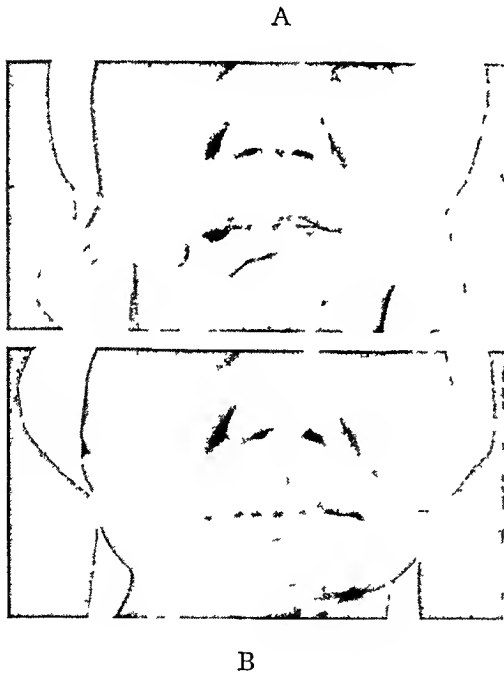


FIG 7—A. Original lesion was radiation necrosis of mandible and overlying skin of the cheek, lip, and chin. Patient shown after removal of damaged bone and full thickness replacement of soft tissue with pedicle flap from the lower neck and upper chest (Fig 6). Continuity of the bone not re-established. B. Improved contour of the mouth and lower face following rib bone-cartilage graft to restore continuity of mandible and support of the soft tissues of mouth and pharynx and contour of face.

inadequate to cover the graft easily and heal readily afterward, it must first be supplemented with a skin graft pedicle flap, or by mobilization of local tissues (Figs 4, 5, 6, 7, 8).

Frequently the loss of a section of mandible is followed by a failure to maintain the remaining fragments in their proper relationship. This permits the ends of the bone to drift together by scar tissue pull so that the space occupied by the original fragment is no longer present. Under such circumstances the contracted scar tissue must be removed before a bone graft can be done. In some instances following this procedure a pedicle flap must be inserted prior to bone grafting.

MANDIBULAR RESECTION

Removal of a section of the mandible creates an immediate problem in management of the remaining fragments.¹ If not held in proper relationship, muscle pull may displace the fragments medially and backward, narrowing the pharyngeal



FIG 8—X-rays of patient shown in Fig 7, mandibular restoration having been made with a rib and attached cartilage, the costochondral junction simulating the angle of the mandible. The inked-in portion represents unvisualized cartilage. Splinting was obtained by driving threaded bar into symphysis and impaling rib on this. The rib symphysis junction was strengthened by applying periosteum taken from other ribs. The cartilage end works in a soft tissue pocket in the region normally occupied by the upper ramus. In this particular type of restoration ordinary methods of splinting are not applicable.

TABLE I—*Appliances Adequate to Control Fragments of Mandible Both after Resection and Bone Graft*¹

A	
Posterior Fragment Edentulous	
a	Arch bar or splint on mandible with posterior extension to hold posterior fragment in line
b	As in "a" except splint attached to maxilla, supplemented by interdental wiring
c	Internal bar fixation (Figs 8, 9, 10, 11, 12)
B	
Both Fragments Edentulous or Teeth Not Suitable for Use	
a	Open bite splint with circumferential wires (possibility of infection of bone graft)
b	Internal bar fixation (Figs 8, 9, 10, 11, 12)

¹ Many appliances suitable for control of fragments after resection are not equally suitable for splinting bone graft because of danger of infection.

funnel, shutting off the airway, and making swallowing both painful and difficult (Fig 9). When such a patient survives these initial hazards, the secondary repair of the bony defect is needlessly complicated by the necessity of restoring these fragments to their original relationship before the bone graft can be done. At the time of resection an accurate and careful soft tissue closure must be made, minimizing the danger of a contracting wound. Mandibular resection is usually performed as a planned procedure.

ture so that an adequate scheme is prepared in advance¹ Occasionally, however, one may be faced with a traumatic loss of bone, creating the same problem (Fig 4) The simplest scheme for the control of bone fragments is to wire the teeth of the fragments to their corresponding maxillary teeth

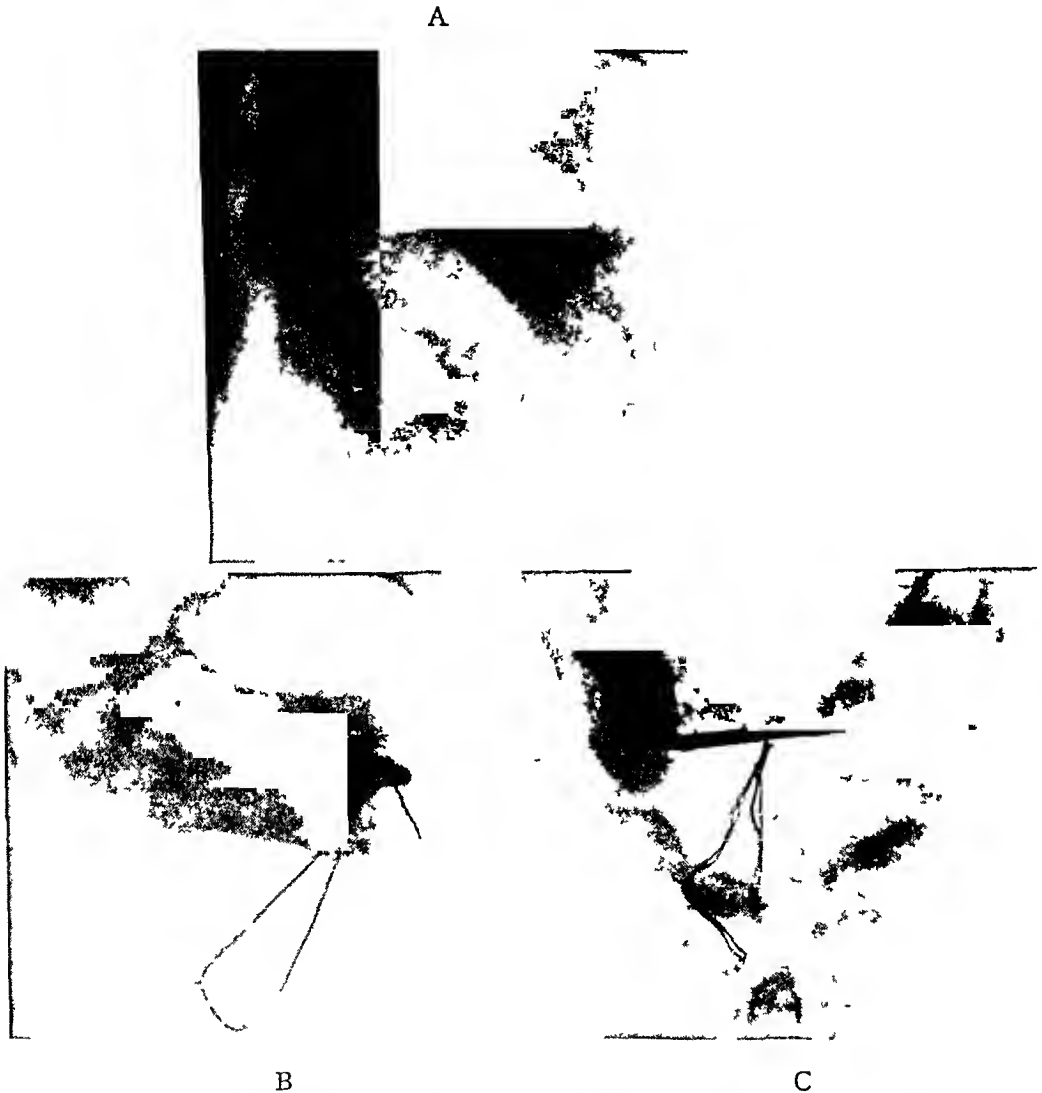


FIG 9—A Roentgenogram of fibrosarcoma of the symphysis B and C Same patient following resection of symphysis area with removal of considerable soft tissue Symphysis resections especially jeopardize breathing because of the detachment of muscle support to the hyoid bone The internal bar has been inserted in the fragments and the larynx is held forward in normal position by a stainless steel wire passed around the hyoid bone Eventually this wire was removed The bar has remained in place without complication (*Surg, Gynec, & Obst*, 84 870, 1947)

(Fig 14) In the edentulous patient or in children, where dental development is inadequate, or in dealing with small posterior fragments, this method is not available Table I indicates the mechanical possibilities which may be used to retain the fragments at the time of resection or as splints at the time of bone grafting under difficult conditions

INTERNAL BAR FIXATION

A method of fixation applicable to traumatic loss of bone under adverse circumstances is the insertion of a bar of tantalum or stainless steel between the ends of the bones, replacing the resected or lost fragment with this sub-

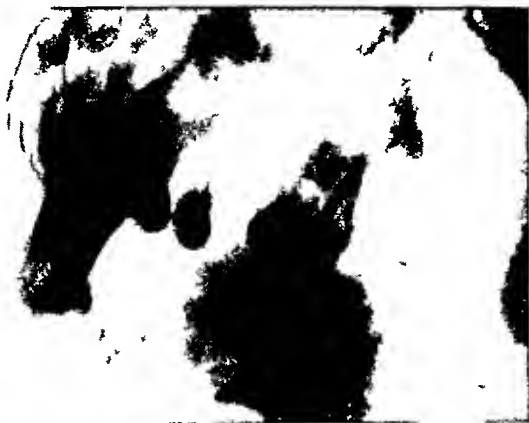


FIG 10—Mandible of an 85 year old man resected along with removal of large amount of soft tissue in treatment for carcinoma of alveolar mucosa. The internal bar as shown preserves pharyngeal support during the immediate postoperative period and although eventually extruded or removed, has remained in place in similar cases, sometimes for many months, giving the patient maximum comfort, even though age and prognosis do not warrant restoration of mandible (*Surg, Gynec, & Obst*, 84: 870, 1947)

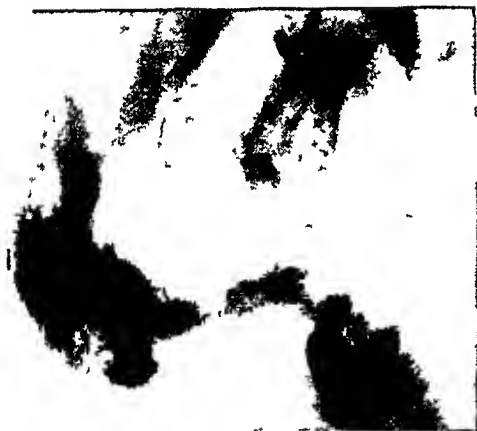
stitute³ (Figs 9, 10, 11, 12). Surprising rigidity results from this procedure, which may be regarded in some instances as a permanent splint for subsequent bone graft (Fig 12), or in other instances merely as a temporary

stop-gap to carry the patient through the trying immediate postoperative time and the later period of wound healing (Fig 10) Not infrequently mandibular resection with widespread soft tissue destruction is performed in cancer patients where restoration of mandibular continuity is not contem-

A



B



C



FIG 11—A X-rays of mandible of an 8 year old child showing tumor later diagnosed microscopically as ossifying fibroma B X-ray following subperiosteal resection and insertion of stainless steel bar to control remaining fragments No further fixation was employed and patient left the hospital healed in ten days C X-ray taken 28 months after operation showing strongly regenerated mandible and presence of original internal splint The patient now is in her third postoperative year without any evidence of trouble from the stainless steel bar X-ray evidence of regeneration was visible 7 weeks after the resection The face is symmetrical (*Plast and Reconstruct Surg*, 1 238, 1946)

plated Here it is desirable to maintain function as far as possible for the comfort and well being of the patient, as well as to have the remaining fragments eventually in as good a position as possible, even though their continuity has not been restored Internal bar fixation has been very valuable under these circumstances Such fixation has been maintained without difficulty for several months, in some instances, years, eventually working free During this period, however, the open wound has healed without contracture,

which would pull the remaining fragments well out of position, had not such fixation been maintained. Even though the patient's age and disease may not warrant complete repair, the disability has been minimized. One extremely difficult problem has been the replacement of half the mandible following resection and disarticulation or resection at the symphysis and high on the ramus, so that the posterior fragment cannot be utilized in the attempted repair. The method which we have most commonly employed has been the use of a rib with its attached cartilage forming a curve simulating the angle and ramus of the mandible, the rib portion representing the body of the mandible (Fig 7). With this type of repair the cartilaginous end has been



FIG 12—*a* X-ray of resected edentulous mandible showing stainless steel bar inserted at time of resection and still in place six months later, having served as a splint for a bone graft done three months after the resection. No fixation or splinting other than this was used. Union is solid to palpation. *b* Appearance of the patient subsequent to bone graft. During the period prior to the bone graft and following the resection, patient was comfortable and could eat soft foods. On palpation the bone fragments were not held rigid but were stable and the patient was comfortable.

inserted in the region near the temporomandibular joint and has worked as a false joint supported by soft tissue. The problem has been to get adequate fixation of the rib to the symphysis, inasmuch as there is no splinting of this fragment other than at the symphysis. All movements of talking or swallowing have a tendency to cause motion in the transplant. The drilling of a threaded stainless steel bar into the symphysis and the impalement of the rib on this bar, bent to the line of replacement, gives firm and adequate immediate fixation, which has been satisfactory for the support of the implant until bony union to the symphysis has occurred (Fig 8). It is desirable to supplement the junction of the implant with the symphysis with other bone-forming material because of the small amount of bone in apposition when the end of the rib is abutted against the symphysis.

SUBPERIOSTEAL RESECTION

Because resection of the mandible is a serious operation from the standpoint of disability, deformity, interruption of function, and difficulty of repair, it is desired to call attention to the operation of subperiosteal resection.² It has frequently been observed that the mandible will regenerate with sur-

A



B



C



FIG 13—A Destruction of mandible from osteomyelitis. There was a pathological fracture and subsequent sequestration of a large segment of mandible. B Beginning regeneration 2 months later. C Adequate regeneration 4 months after sequestrectomy. Similar regeneration occurs following subperiosteal resection. (*Surg, Gynec, & Obst*, 84: 870, 1947)

prising adequacy after the spontaneous sequestration of large segments following osteomyelitis (Fig 13). Similar regeneration will occur following subperiosteal resection (Fig 11). Obviously this procedure cannot have widespread application. Rarely would it be adequate in the treatment of any of the malignancies. Occasionally in dealing with the simpler tumors, such as adamantinomas, ossifying fibromas, or osteomas, which have caused extreme

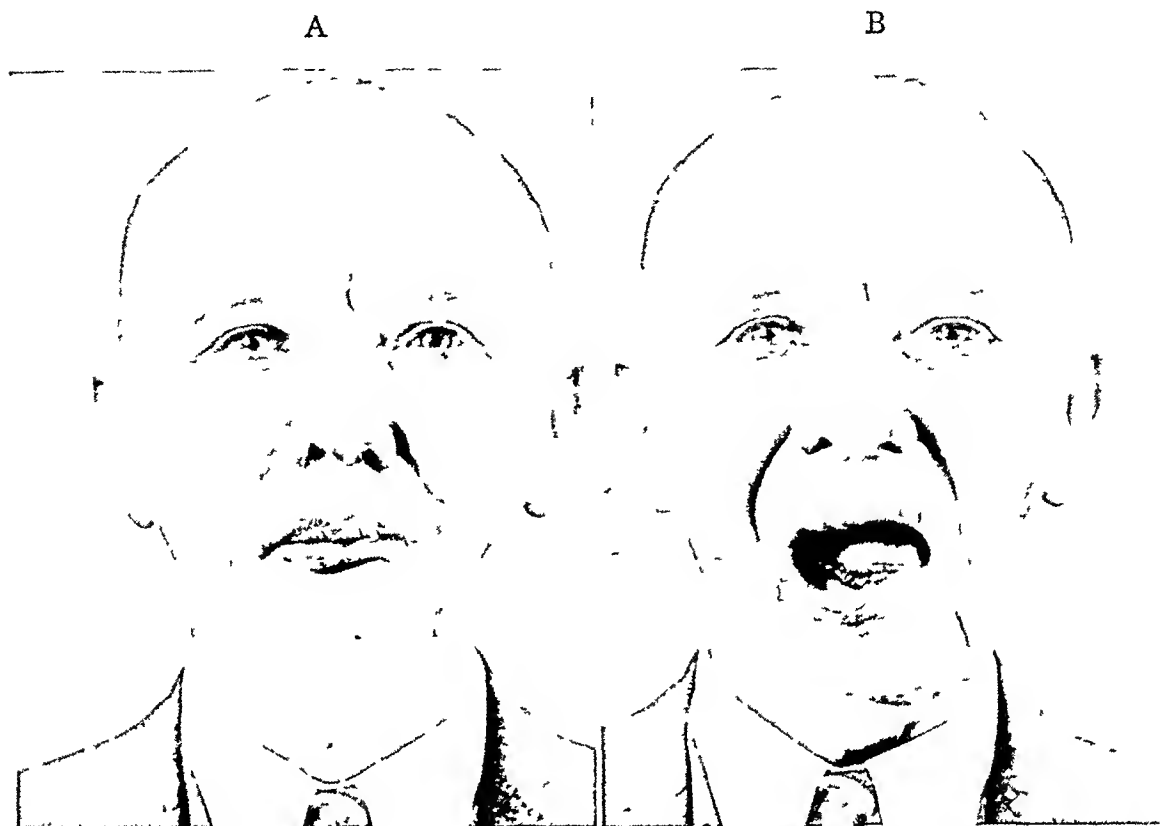


FIG 14—A Resection of symphysis and disarticulation of half the mandible, along with removal of full thickness of the cheek for carcinoma. Such a wound may create sufficient traction in healing to displace remaining half of mandible markedly. Note relative symmetry of normal portion of face obtained by holding remaining fragment of mandible in occlusion throughout healing period. B Mouth opening is possible because of the missing mandible on the left side. Such removal of soft tissue without replacement will greatly limit mouth opening if the mandible is intact. Maximum function short of reconstruction has been preserved (*Surg, Gynec & Obst*, 84: 870, 1947)



FIG 15—A Extreme microgenia from early childhood infection. Functional improvement to a marked degree is not feasible because of weakness of the bite. However, some improvement in function and a great improvement in contour was gained ("B") by (1) building forward the mandible with cartilage implants, (2) supplying additional soft tissue to the chin, (3) creating skin graft lined pocket inside the lip, and (4) fitting with denture, utilizing a few remaining teeth and the cartilage implant for support.



FIG 16—A Congenital underdevelopment of the mandible with good function Improvement of contour sought for professional reasons B Building forward the mandible with cartilage implant gave much more pleasing contour

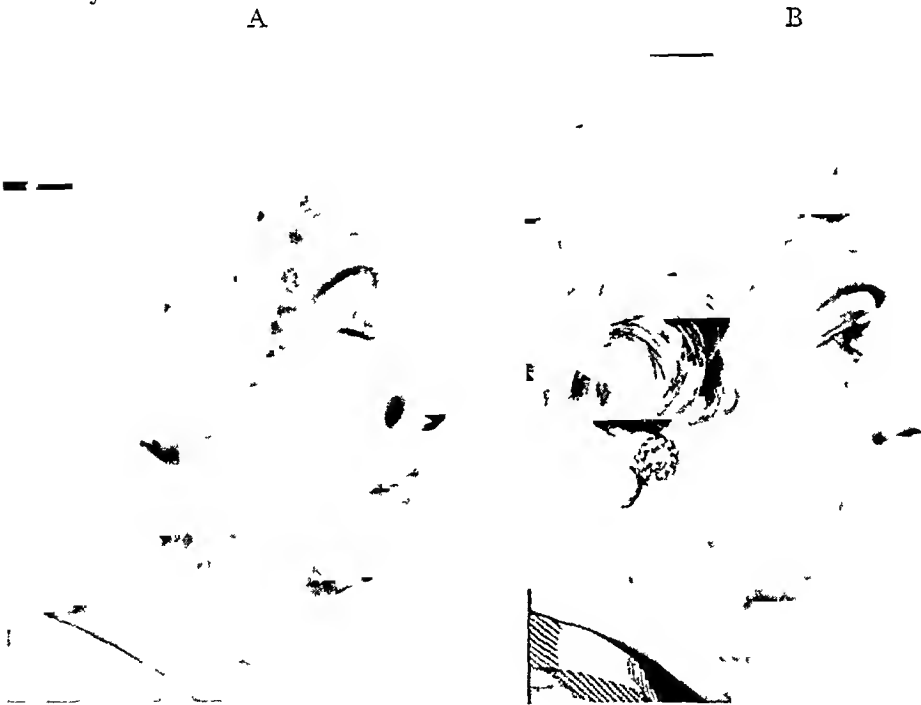


FIG 17—A Congenital maldevelopment with unpleasing facial contour B Improved by bringing forward mandibular prominence with cartilage implant and correcting unattractive nose at the same operation by nasoplasty

expansion of the bone, the entire thickness of the bone must be removed in order to effect a cure, but the periosteum is uninvolved and at least portions of it can be left bridging the gap between the ends. If these fragments are adequately controlled, regeneration will readily occur. In children especially the usual forms of splinting are often unsatisfactory, and in such cases internal bar fixation, counting on the bar to be permanent and to be rapidly supplemented as a supporting structure by regenerating bone, is the best scheme.

MANDIBULAR CONTOUR

In some instances of extreme underdevelopment or maldevelopment of the mandible, function cannot be restored to a normal degree because of

A

B



FIG 18—A Condition similar to that illustrated in Fig 17. B Correction by cartilage implant to chin and nasoplasty (*Surg, Gynec & Obst*, 84: 65, 1947).

the lack of muscular power exercised by the closing muscles on the remnant of bone present. In such cases restoration of contour with good appearance of the patient is most important. In the extreme cases, not only must the solid prominence of the mandible be extended forward, but room for a denture to supplement the mandible still further must be created (Fig 15). The first consideration involves the use of a cartilage or bone graft to the prominence of the mandible or to the flattened side, if asymmetry is present, to give as much prominence as possible (Fig 1). In extreme cases soft tissue in the form of a pedicle flap must be supplied prior to the cartilage or bone implant in order to create room for it. Subsequently, additional space inside the lower lip must be obtained by the creation of a skin graft lined sulcus,

this combination building forward the solid portion of the mandible to form a shelf on which a denture can rest, and supplying room for the denture will give great improvement in appearance although there is little power to the bite. In less extreme cases where function is adequate, but the appearance is unpleasing, creating the missing contour with implants of cartilage applied directly to the bone as a single procedure will give good improvement in appearance. Such implants must be applied directly to the bone without a superimposed layer of soft tissue to insure solidity of the implant with the mandible (Fig 16). Additional improvement in appearance may be often obtained by correction of other asymmetries of features, combining in some instances a nasoplasty with restoration of mandibular contour (Figs 17 and 18).

OTHER CONSIDERATIONS

Fractures, limited removal of bone of the alveolus, as for tumor involving the alveolar ridge, or removal of soft tissue obliterating a sulcus, may interfere with the successful fitting of dentures. If an adequate alveolar ridge is present, the other factors usually may be corrected simply. Obliteration of the buccal sulcus can be corrected by adequate incision in the buccal sulcus and the application of a split thickness graft to maintain the depth of the sulcus.

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- ¹ Byars, L T, and B G Sarnat Surg, Gynec & Obstet, 81 575-584, 1945
- ² Byars, L T Plast & Reconstruct Surg, 1 236-239, 1946
- ³ Byars, L T, and Frank McDowell Surg, Gynec & Obstet, 84 870-877, 1947

DISCUSSION—DR TRUMAN G BLOCKER, JR, Galveston, Texas. I have enjoyed Doctor Byars' presentation a great deal and recognize his vast experience in handling cases requiring jaw restoration. In the army, where a large number of jaw reconstructions were necessary, our patients came to us with such loss of soft tissue or such intensive scarring in the area of bony loss that it was impossible to maintain occlusion of the intact fragment. We found, however, that when the scar tissue was replaced by a supple pedicle, the fragments tended to return to their approximate normal position, occasionally requiring elastic traction.

The toothless posterior fragment, even though it may be considerably misplaced, can frequently be brought into proper alignment at the time of bone grafting by stripping its muscular attachments and forcibly bringing it into position with a wire placed through the angle.

I feel that Doctor Byars' method of placing a bar between the fragments has considerable merit. But where there is loss of soft tissue or where the bone is exposed, I would be hesitant to use an internal splint because of the danger of infection.

DR LOUIS T BYARS, St Louis, Mo (closing). I have heard this method of repair criticized and the statement made that good results often were not obtained by it. I believe when the results are disappointing it is because the operator does not have the courage to do the tremendous amount of overcorrection that is necessary and, in the subsequent relaxation, the support is lost. I have never seen one that was overcorrected, and I have seen a number where strips had been tightened or should have been tightened later.

PROLAPSE OF THE GASTRIC MUCOSA*

Report of Six Cases

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PROLAPSE OF THE GASTRIC MUCOSA through the pylorus has been considered an unusual phenomenon, and relatively few cases have been reported. The first case was reported by Von Schmieden in 1911.¹ Melamed and Hiller,² in a review of the literature in 1943, found only 19 cases reported. Scott³ reviewed the admissions of a large Naval hospital for the years 1943-1944. In 19,288 admissions, 1,346 examinations of the upper gastro-intestinal tract were made, and in this group 14 instances of prolapse of the gastric mucosa were found, an incidence of 1.04 per cent. In the same series, 13 cases of gastric ulcer were found, an incidence of 0.96 per cent. Rees⁴ found only four cases in 3,000 such examinations at the Rees-Stealy Clinic, and only two cases in 2,550 examinations at the San Diego County General Hospital. Archer and Cooper⁵ believe that the disease occurs much more frequently than is commonly recognized, but they do not give the incidence. Pendergrass and Andrews⁶ report that in the Department of Radiology of the University of Pennsylvania, the condition was diagnosed in 99 patients from 1923 to 1935. They do not, however, give the total number of examinations made during this period.

In a review of the last 97 examinations of the upper gastro-intestinal tract made at the white division of Grady Memorial Hospital, Atlanta, seven cases were diagnosed, an incidence of 7.2 per cent, in the last 100 such examinations in the colored division of Grady Hospital, nine cases were diagnosed, an incidence of 9 per cent, and in 100 gastro-intestinal examinations made at Emory University Hospital, 7 cases were diagnosed, an incidence of 7 per cent. Of the 297 total examinations reviewed at the two hospitals, 23 cases of prolapse of the gastric mucosa were found, a total incidence of 7.7 per cent.⁷ Of the 23 cases, four were so extensive as to indicate eventual surgical treatment.

The condition is most often observed in patients in the fourth decade of life, although it has been seen in patients ranging in age from 20 to 80 years. Of the six cases presented here, five occurred in males. The incidence did not vary according to race.

ETIOLOGY The etiology of prolapse of the gastric mucosa is unknown. Eliason and Wright⁸ suggest that it is the result of a low-grade inflammation of the mucosa produced by chronic irritation, and that it develops into a local hypertrophy. Once this hypertrophy begins, it is increased mechanically by contraction of the stomach, peristaltic waves, and the pressure of the gastric contents as they are forced by on their way to the pylorus. The mucosa is

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Wednesday, December 10, 1947.

thus pushed along or lengthened out in the direction of the pylorus, and it is eventually swept into the pylorus by a peristaltic wave, causing a ball-valve syndrome attack of pain. Rubin⁹ concurs in this theory of an inflammatory origin but believes also that the resulting increase in peristalsis causes a progressive prolapse of the mucosa. Wolf and Wolff¹⁰ found great variation in the thickness of normal mucosa, various stimuli causing large hypertrophic-appearing folds of mucosa which subsequently appeared normal. In three cases of prolapsed gastric mucosa treated surgically, Rees⁴ found a "definite resistant narrowing of the pylorus and an apparent loss of muscular substance," suggesting a fibrous degeneration of the muscular tissue. He believes that this narrowing of the pylorus causes hyperperistalsis which in turn loosens the



FIG 1 Case 6 Upper left illustration shows extreme mobility and redundancy of the gastric mucosa. On the right is shown the rugae continuing down well past a normal pyloric aperture into the duodenum.

attachment of the mucous membrane to the muscularis in the constricted area, and that once the membrane is mobilized, the traction is transmitted by continuity to the antral mucosa, which is loosened in turn and eventually prolapses. He states that the condition is progressive and symptoms become more pronounced as the mucosa becomes more redundant. Scott³ believes that none of these hypotheses will completely explain the condition. Rather, he believes that the mucosa becomes loosened as a result of stretching during normal gastric movements, and he cites Forssell's and Schindler's observations that the mucosa has a mobility of its own, and varies in size, shape

and position independently of the contractions of the muscularis. He states that "the one common denominator in the theories on the etiology of prolapse is an abnormal disturbance of gastric peristalsis and function. The most common continuous and effective means for altering gastric function springs from the emotions and the nervous system. Consequently, in view of the construction of the stomach walls, which normally permits a degree of mobility between them, it seems possible that certain neurogenic factors are the inciting cause of a disturbed gastric function that ultimately brings about a mucosal prolapse. A pre-existing disease process is not necessary for the production of a prolapse of the gastric mucosa."

PATHOLOGY The pathology involved in prolapse of the gastric mucosa is a redundancy of the mucosa of the pyloric end of the stomach with greatly hypertrophied rugae. This area of mucosa not only becomes redundant, its mobility on the muscularis is greater than normal. Observation at autopsy has shown the mucosa of the normal stomach to be movable on the muscularis, but in no case sufficiently mobile to allow it to be drawn down into the duodenum. In the one case operated upon at Grady Hospital, there was such marked redundancy and mobility of the prepyloric mucosa on the muscularis that the mucosa could be drawn down into the duodenum 6 to 7 cm. beyond the pylorus (Fig. 1). The pyloric muscle was greatly hypertrophied, but the lumen of the pylorus was apparently normal, and the mucosa could be passed in and out of it without difficulty. In this case the prolapsed mucosa could be felt through the duodenal wall, but this was not possible in the majority of cases reported in the literature. The rugae of the stomach were continued on to the prolapsed mucosa. Microscopic examination of the resected mucosa revealed hyperemia and many blood cells throughout but no other evidence of inflammatory change. Some observers have found inflammatory infiltration into the mucosa,^{2,8} others have found a narrowing of the pylorus with loss of muscular substance.⁴ The presence of ulcers, polyps, and carcinoma on the prolapsed mucosa has been reported.^{9,2} However, none of these findings have been consistently confirmed by most observers.

SYMPTOMATOLOGY Pain is the most consistent single symptom and may be either aching or cramp-like in character. It is usually felt in the epigastrium, and frequently radiates either under the costal margin or to the back. It may be prostrating. It occurred in four of the six cases presented here. Nausea and vomiting occurred in five of the six cases. Four of the six had sour belches or heartburn. Four of the patients had hematemesis and melena. Variation of the degree of acidity of the stomach does not appear to be distinctive. Anorexia, anemia (which Archer and Cooper⁵ believe has not been adequately stressed as a commonly occurring symptom), and loss of weight may be dominant symptoms. Varying degrees of gastric retention, or none at all, may be present.⁴ Thus, it can be seen that these patients present a variable group of symptoms similar to those presented by patients with peptic ulcer.

DIAGNOSIS There is no definite combination of symptoms common to all cases that will allow the diagnosis to be made from clinical observations alone. Roentgenographic examination is essential in arriving at a diagnosis, and fortunately the findings of this examination are distinctive. There is a filling defect in the duodenum, characterized by a central streak of barium showing an intact mucosa.⁴ This defect is variable depending on the degree of prolapse of the mucosa and the motor activity of the stomach at the time

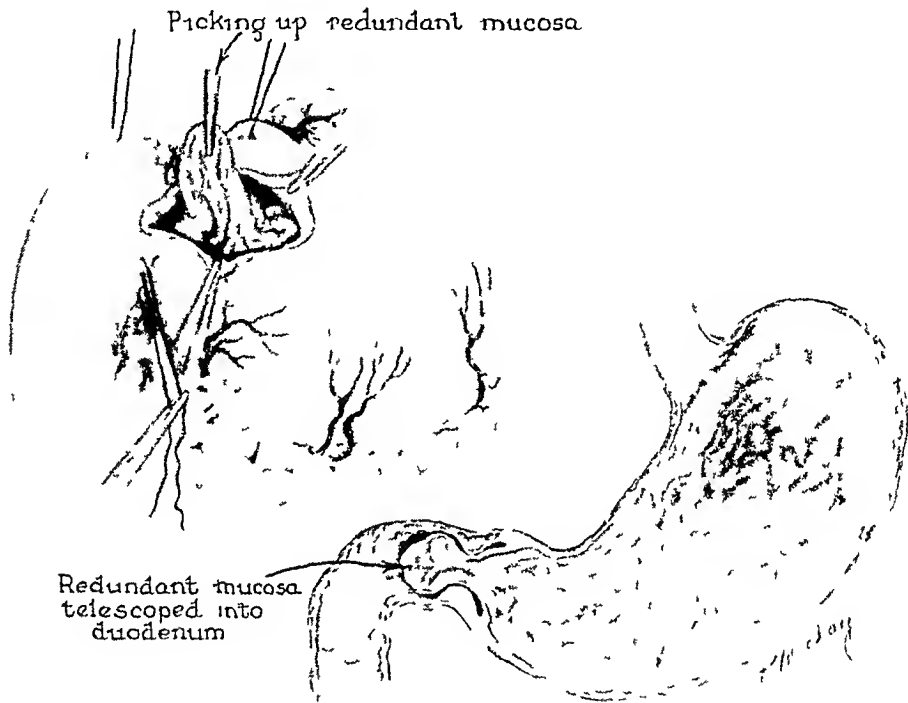


FIG 2 Case 6 Marked prepyloric deformity with folding out of mucosa into the duodenal cap

of examination. The mucosa prolapsed into the duodenum allows the barium to flow around it, producing a characteristic mushroom or umbrella effect. Usually the redundant gastric rugae can be traced from the antral canal through the pyloric opening into the base of the duodenal bulb. The rugae in the prepyloric portion of the stomach do not appear abnormal or particularly large.³ The duodenal bulb is not irritable, it usually retains the barium, thus permitting prolonged examination, a contradistinction to the behavior of the bulb with an active ulcer or duodenitis.³ Pendergrass and Andrews⁶ have summarized the roentgenographic findings as follows:

- 1 Prolapsing lesions of the gastric mucosa produce a central filling defect in the duodenal cap, and there is a thin shadow of bismuth around the defect.
- 2 The defect is generally not seen in films made in the erect posture.
- 3 The diagnosis can be easily overlooked in the fluoroscopic examination.

- 4 There is no disturbance in the passing of the peristaltic waves
- 5 There is always a six-hour residue (This was not consistently found in the cases observed at Grady Hospital)
- 6 There is no defect of the stomach in the presence of pedunculated growths which prolapse through the pyloric ring
- 7 There is a variable defect of the prepyloric region of the stomach when prolapsed mucous membrane extends through the pyloric ring

TREATMENT The curative treatment of this entity is unquestionably surgical and is directed toward removing the prolapsing mucosa, short circuiting the diseased area, or enlarging the gastric outlet so that the prolapsed mucosa can move back and forth at will without causing obstruction

Indications for operation are (1) persistent pain, (2) hemorrhage, and (3) obstruction. Many cases with lesser degrees of prolapse are amenable to dietary management and the administration of antispasmodics. It must be remembered that "the condition is progressive and symptoms become more pronounced as the mucosa becomes more redundant"⁴

Many types of surgical procedures have been used to correct the deformity, including partial gastrectomy, pyloroplasty, gastrojejunostomy, and simple excision of the redundant mucosa. In the one case treated by surgery at Grady Hospital, the redundant mucosa was excised and the appronemated edges were sutured to the muscularis, and a Finney pyloroplasty was done. Probably any procedure that effects removal of the mucosa or gives it freedom to move back and forth without causing obstruction or becoming incarcerated would prove satisfactory.

CASE REPORTS Summaries of the six cases from the surgical service of Grady Hospital are presented here.

Case 1—E. W., female, Negro, age 23. This patient was admitted June, 1942, complaining of dull aching pain over the left costal margin, more severe when the stomach was empty, not relieved by taking food. She had eructation of sour material, and on three occasions vomited small quantities of blood, the last episode occurring about one week before admission.

Roentgenographic examination revealed prolapse of the gastric mucosa through the pylorus. There was no evidence of ulcer. She was treated with antacid powder, belladonna, and a fairly liberal diet eliminating greasy foods. There was no further bleeding, and digestive symptoms were relieved. This patient was last seen in 1944, at which time she stated that she was fairly free from digestive symptoms as long as she remained on the diet.

Case 2—L. W., male, Negro, age 39. In January, 1939, this patient vomited dark blood, passed dark, tarry stools, had sudden weakness and blind staggers. He came into the hospital three days later and was treated with Sippy diet and Amphojel for three days. After roentgenologic examination, a diagnosis of hypertrophic gastritis with prolapse of the gastric mucosa was made. He was treated symptomatically, the bleeding stopped, and the patient left the hospital against advice. He was readmitted in September, 1939, and July, 1940, each time following an episode of hemorrhage, and each time the patient left the hospital without permission. In February, 1943, he was admitted to the surgical service because of exsanguinating hemorrhage. Transfusions were given and he recovered.

from shock. Roentgenographic examination at that time revealed prolapse of the gastric mucosa into the duodenum. The patient refused surgery and left the hospital.

Case 3—J. A., male, white, age 39. This patient was admitted July 17, 1939, complaining of attacks of epigastric pain, nausea, vomiting, heartburn and indigestion for the previous five years. There was tenderness in the right lower quadrant, and an appendectomy was performed on the day of admission. Pathologic examination showed a normal appendix. Patient left the hospital unimproved. He was readmitted in April, 1945, complaining of having vomited undigested food after meals for a period of ten months. He had never vomited blood. He had had a cholecystectomy at another hospital in January, 1945. Following this operation he had complete relief for three to four weeks, following which he again started vomiting and had almost constant retrosternal pain.

Gastro-intestinal examination showed the pylorus to be somewhat narrowed but the mucosa appeared normal. There was a crescent-shaped filling defect observed in the base of the duodenal cap, representing an hypertrophy of the pylorus and prolapse of the pyloric mucosa into the base of the duodenal cap. Patient left the hospital without permission on April 28, 1945, and was re-admitted in October, 1947, with the same complaints. On a bland diet with belladonna at mealtime he has remained entirely well and has had no further vomiting. This patient had no anemia and vomited no blood at any time.

Case 4—J. L., male, white, age 70. This patient was admitted May 18, 1944, in a coma following subarachnoid hemorrhage. His blood pressure was 190/120. In addition to other difficulties, he had suffered from substernal pain, heartburn, nausea and vomiting over a period of three years, and had passed tarry stools. Gastro-intestinal examination revealed the folds of mucosa in the pylorus to be very thick and to have herniated into the duodenal cap, indicated by a crescent-shaped filling defect in the base of bulb. There was no evidence of ulcer. The patient was placed on a bland diet with antispasmodics. He has had no further discomfort.

Case 5—H. W., male, white, age 49. This patient has had digestive disturbances for the past three years. He has been under considerable emotional strain and has had numerous attacks of substernal pain radiating through to the back. These attacks are relieved by opiates and antispasmodics. For about six weeks following an attack, this patient has all the clinical symptoms of peptic ulcer. A physician, he treats himself over this period with a rather strict diet, between meal feedings, and antispasmodics, and apparently entirely recovers. He is then able to eat normally until the next episode of substernal pain and ulcer symptoms. Repeated roentgenographic examinations have never shown a definite ulcer crater, but there is a definite prolapse of gastric mucosa through the pylorus. It is believed that this prolapse occurs periodically, producing the symptoms of ulcer, but whether actual ulceration occurs on this prolapsed mucosa is a matter of speculation.

Case 6—J. M., male, Negro, age 35. For several years this patient had attacks of abdominal pain beginning in the epigastrium and radiating to the back under the right shoulder blade. These attacks, which lasted two or three hours, were accompanied by heartburn, belching, and occasional vomiting of undigested food. He would take laxatives and recover completely until the next seizure. During an attack July 13, 1947, he vomited about a quart of bright red blood. He continued vomiting until he collapsed. He was admitted to Grady Hospital, July 14, 1947, in a state of shock. His pulse was weak, blood pressure was 80/50, he was sweating and had some air hunger. Hemoglobin was 6.9 Gm., red blood count was 2 million. He passed several dark, tarry stools. After four transfusions the blood pressure rose to 150/80, hemoglobin to 12 Gm. On July 16, 1947, patient had another episode of bleeding and lost about 1,200 cc. of blood which was replaced by whole blood transfusion. Roentgenographic examination the following day revealed a pronounced prolapse of the gastric mucosa into the duodenal cap, indicated

by an umbrella-like filling defect in the pyloric side of the duodenal cap (Fig 2) No other significant changes were noted

This patient was operated upon August 7, 1947 After the stomach and pylorus were exposed, it was possible to feel the prolapsed mucosa extending for approximately 2.5 cm into the duodenum The stomach was opened by a horizontal incision on the anterior surface The rugae in the prepyloric region of the stomach were very large and were unattached to the muscularis The mucosa had prolapsed through the pyloric sphincter With an Allis forcep this loose mucosa could be lifted up in a definite collar-like fold for a distance of 5 or 6 cm through the incision in the stomach (Fig 1) The rugae were directed into this collar of mucosa and went on into the duodenum The collar of mucosa was excised locally and sutured with 00 catgut, taking care to anchor it to the submucous layer Although the pylorus was patent and appeared normal in size, it was thought wise to transect this muscle The stomach incision was therefore extended on to the duodenum and a classic Finney pyloroplasty was done No evidence of ulcer was found The site of the bleeding was not located The mucosa was of normal color and appearance

The patient became ambulatory the following day Roentgenographic examination showed no evidence of further prolapse, but an enlarged, rather deformed-looking pylorus now exists The patient had no further symptoms and was discharged from the hospital August 19, 1947 He was last seen November 25, 1947 and had been entirely symptom free since operation

SUMMARY

1 Prolapse of the gastric mucosa through the pylorus is a distinct clinical entity

2 This condition occurs rather frequently, being found more often than gastric ulcer In a review of the last 297 examinations of the upper gastrointestinal tract made at Grady Memorial and Emory University Hospitals, 23 cases were found, an incidence of 7.7 per cent

3 The diagnosis may be easily missed This disease may well be the underlying factor in many of the undiagnosed digestive disturbances

4 The etiology is unknown

5 The pathology is an abnormal mobility and redundancy of the prepyloric mucosa with prolapse through the pylorus

6 The symptomatology is not clearly defined

7 Roentgenographic examination is essential in making the diagnosis The findings are distinctive

8 The curative treatment is surgical, but milder cases can be successfully treated by dietary management and antispasmodics

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DISCUSSION —DR T C DAVISON, Atlanta, Ga I would like to ask what produces the symptoms Is it obstruction in the pylorus?

DR IRA A FERGUSON, Atlanta, Ga (closing) We thought the symptom of pain was probably produced by spasm of the pyloric sphincter There is, of course, a question as to whether the prolapsed mucosa becomes strangulated or so incarcerated in the pyloric aperture that it interferes with the blood supply We think this is a possibility as hemorrhage is a commonplace symptom However, the most likely cause is pylorospasm

MESENTERIC VASCULAR OCCLUSION*

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THE COMPREHENSIVE TERM mesenteric vascular occlusion is usually limited in its application to obstruction of the mesenteric blood vessels by thrombosis or embolism. The condition is very common if we include the thrombosis, usually of minor degree, that occur as part of the picture of gangrenous appendicitis, peritonitis, strangulated hernia, operative trauma, etc. This discussion will be limited to mesenteric vascular occlusion due to thrombosis or embolism resulting from causes other than local infection or injury.

Our interest in this subject has been revived by our recent observation of 11 such cases, which has impressed upon us the facts that the clinical picture is not too difficult to recognize, and that this must be done earlier than it usually is if treatment is to be effective.

We are reporting 19 cases found in the records of Touro Infirmary in the ten year period from 1938 to 1947. Eleven have been observed by one or another of us within the last two years. (See Table I.)

A fairly comprehensive review of the literature combined with our own observations reveals certain facts as to etiology and pathology that are well established.

1 The common statement that the terminal branches of the mesenteric arteries are "functional end arteries"³² is true only in the sense that they do not have anastomoses between their larger branches. They communicate with each other freely through the profuse submucous plexus.

2 There is considerable variation in the efficiency of this collateral circulation as is shown by the facts that

a Experimental ligation of a single terminal artery has little or no effect.^{27, 49}

b Two cases in our series showed focal necrosis and perforation from embolic occlusion of single small arteries. This, no doubt, resulted from progressive thrombosis beyond the site of occlusion which obstructed the collateral channels in the submucosal plexus.

c Whereas Welch and Mall found that occlusion of the arterial supply of 5-10 cm of the bowel regularly caused gangrene, Rothschild found that, in dogs, 10-15 cm could be deprived of its blood supply with survival of the bowel in about half the cases. It has been suggested¹² that vasospasm of the patent collaterals may in some instances account for this variation.

3 Obstruction of an artery proximal to the terminal arcade leaves adequate collaterals except in the case of very large vessels such as the superior or inferior mesenterics.^{27, 49, 56} The collateral anastomoses of such arteries are too

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Wednesday, December 10, 1947.

TABLE I—Summary of Findings and End-result of the 19 Reported Cases

Case	Age	Sex	Pathologic Type	Predisposing Cause	Onset—Duration	Site	Gangrene Diagnosed	Operation	Result
1	60	M	Embolie Arterial	Embolus from mural Thrombus	Masked	Smaller Vessels Producing Only Mesenteric Infarction Superior and Inferior Mesenteric Arteries	No	None	Died
2	40	M	Arterial	Embolus from mural Thrombus	Masked	Terminal Ileum, Cecum, and Ascending Colon	Yes	None	Died
3	75	M	Arterial	Embolus from mural Thrombus	24 hours	Jejunum, 3½ cm	Yes	Jejunostomy	Died 24 ho p o
4	57	F	Arterial	Rheumatic Valvular Heart Disease	6 hours		Yes	None	Died
5	67	F	Arterial	Embolus from Atheromatous Plaque-Aorta	3 days	Jejunum, 3½ cm	Yes	None	Died
6	67	M	Arterial	Embolus from mural Thrombus	1 Insidious 5 days 2 Sudden onset	Jejunum, Ileum, Ascending, and Transverse Colon	Yes	Resection—Side-to-side Anastomosis	Died
7	57	F	Thrombotic Arterial	Peripheral Arteriosclerosis	48 hours	Entire Small Bowel, Cecum, Ascending Colon	Yes	None	Died
8	74	F	Arterial	Peripheral Arteriosclerosis Heart Failure	Masked	Jejunum and Ileum	Yes	None	Died
9	75	M	Arterial	Arteriosclerosis Aorta	96 hours	Small Bowel, Cecum Ascending Colon	Yes	None	Died
10	72	F	Arterial	Idiopathic	3 days	Entire Ileum	Yes	None	Died
11	62	F	Venous	Idiopathic	7 days	Ileum, 3 feet	Yes	Resec —end-to-end anastom	Died 30 days p o
12	57	F	Venous	Idiopathic	24 hours	Terminal Ileum	Yes	None	Died
13	69	M	Venous	Phlebo Sclerosis Congestive Heart Failure	6 hour sudden terminal onset	Lower ¾ Jejunum, Entire Ileum	Yes	None	Died
14	26	M	Venous	Disseminated Lupus Erythematosus	8 days	Jejunum and Ileum	Yes	Died on Op Table prior to incision	Died
15	45	M	Venous	Portal Hypertension	1 36 hours 2 36 hours	1 Ileum 2 3 feet	Yes	Resec —side-to-side anastom	Died 8 days p o
16	48	M	Arterial & Venous	Idiopathic	3 weeks	Ileum, 12 feet	Yes	Resec —end-to-end anastom	Recovered
17	58	M	Arterial & Venous	Intestinal Lipodystrophy (Whipple's Disease)	72 hours	Ileum 1½ feet	Yes	Resec —end-to-end anastom	Died 2 days p o
18	30	M	Arterial & Venous	Idiopathic	6 days	Terminal Thrombosis	No	Enterostomy	Died 1 day p o
19	62	M	Arterial & Venous	Idiopathic	3 days	Distal Ileum	Yes	Ileostomy	Died 2 days p o

small and too widely separated to provide adequate blood supply for so long a segment of bowel

4 Gradual occlusion of any artery, even the superior mesenteric, may be well tolerated, in fact, if it is very slow, no recognizable symptoms may occur⁵⁰⁻⁵³

5 Partial occlusion, sudden or gradual, of the arterial supply of any segment of bowel, whatever its length, may cause only minor disturbances of function. However, such a partial occlusion that has been well tolerated when the general circulation was good, may cause infarction when at a later date the

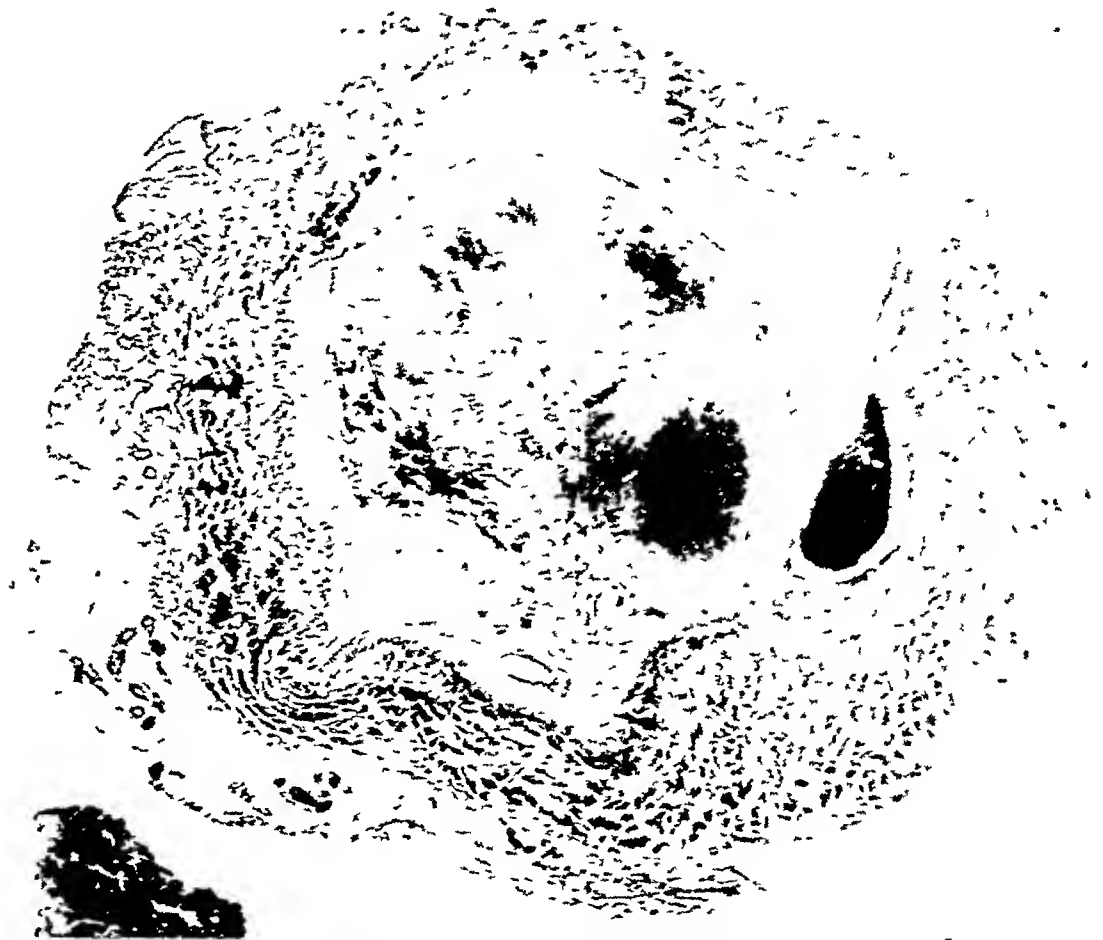


FIG. 1—Subtotal occlusion, mesenteric vein, old. Increased portal pressure due to cirrhosis of liver and possible heart failure superimposed on the portal occlusion produced complete occlusion of mesenteric veins and gangrene. X-18

efficiency of the general circulation is impaired.⁷ Welch and Mall observed experimentally that when all collaterals to a segment of bowel were ligated and the mesenteric artery gradually occluded infarction took place when the pressure distal to the occlusion fell to $\frac{1}{5}$ of normal. Two of our cases showed this phenomenon and in addition one showed the same effects from partial occlusion of the superior mesenteric vein (Fig. 1)

6 Simultaneous thrombosis of both arteries and veins is probably rare but involvement of either is often followed by thrombosis of the other and it is usually difficult or impossible for the pathologist to determine the site of the

beginning of the process Donaldson and Stout⁸ have shown experimentally that spread of thrombosis from veins to arteries does not always occur Five of our cases gave histologic confirmation of this observation and four show that the converse is also true

7 All infarcts of the intestine are hemorrhagic⁵⁵ Why arterial occlusion causes hemorrhagic infarction is not entirely clear It may be due to reflux of blood from the veins actuated by the positive portal pressure¹⁵ or to the flow of arterial blood into the submucous plexus from anastomosing arteries⁵⁶ It is difficult to see how the latter explanations can apply to infarcts resulting from occlusion of major arteries because of the great length of bowel intervening between the patent collaterals

8 The pathologic and physiologic changes caused by mesenteric vascular occlusion are the same in arterial, venous, and combined involvement Depending upon the degree of ischemia produced, the effect upon the bowel may be (1) none, (2) paralytic ileus without pathologic change other than congestion, (3) ulceration of the mucosa, (4) ecchymoses into the bowel wall, (5) hemorrhagic infarction, focal or massive, and (6) finally, perforation When the process progresses as far as ulceration, blood is usually extravasated into the lumen When infarction takes place, there is extensive hemorrhage into the lumen of the bowel, edema and hemorrhagic infiltration of the mesentery, and transudation of fluid, usually bloody, into the peritoneal cavity

9 As a rule, little or no gas accumulates in the involved, segment, presumably due to the fact that the infiltrated intestinal wall is not readily distensible Chesterman,³ from observations on cats, concluded that distention is prevented in the earlier stages by tonic contraction of the involved bowel

In one of our cases, although there was extensive gangrene, there was only slight distention of the small bowel, despite roentgen-ray evidence of a few fluid levels

10 When ischemia of a segment of bowel takes place, hyperperistalsis occurs for a period reported to be as long as two to three hours^{45 56} This is followed, after a variable time, by paralytic ileus, which has the effect of producing partial intestinal obstruction with all of its associated phenomena²³ At any time before gangrene develops, the process may be arrested and complete recovery takes place This is probably a common event in minor degrees of thrombosis⁸ We have previously observed this phenomenon and the histological examination of the autopsy specimen in one of our cases shows old recanalized thrombi as evidence of two previous similar episodes (Fig 2) Recurrence of mesenteric vascular occlusion is especially likely in portal hypertension and in mesenteric arteriosclerosis^{5, 11}

HISTORICAL

The first case was reported by Tiedemann⁵⁰ a little over one hundred years ago Virchow⁵³ four years later in 1847 described the pathology The clinical picture received scant attention until Litten's³² paper in 1875 Councilman⁷ in

1895 commented on the tendency of rare pathological conditions to occur in groups and detailed the autopsy findings in three cases of superior mesenteric occlusion seen in a two-week period

Elliott¹⁴ could find only three surgically treated cases prior to 1895, all unsuccessful. He reported two cases seen within a fortnight. The first was a 24-year-old male, in whom it was necessary to resect four feet of gangrenous jejunum. The open ends of the intestine were stitched into the abdominal wall,

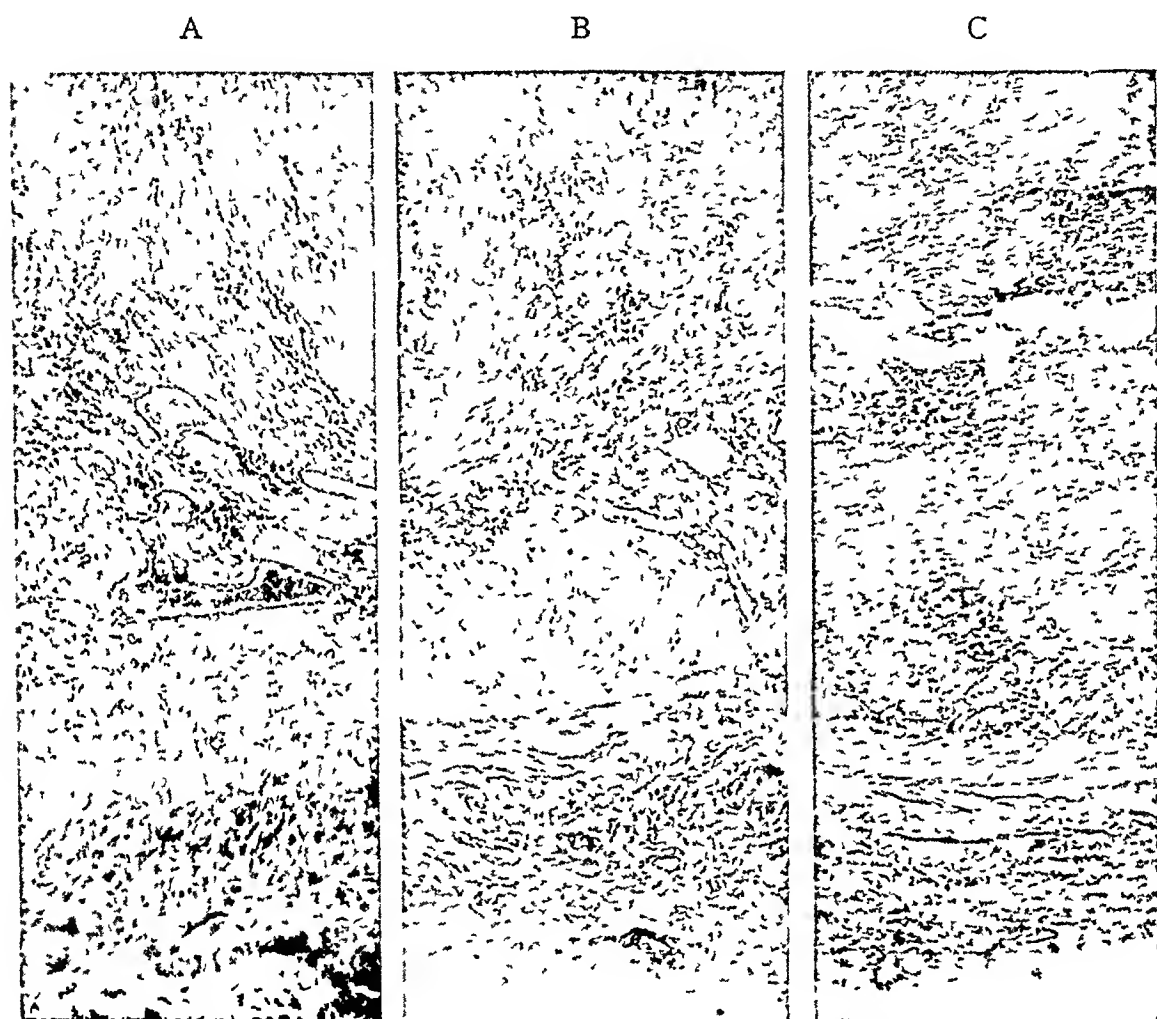


FIG 2—Progressive phases of thrombosis, organization, and recanalization. Section (a) old, (b) intermediate, and (c) recent. X-60

and closure was performed two weeks later. This was the first successfully treated case.

Welch and Mall,⁵⁶ in 1899, reported their results on experimental mesenteric vascular occlusion in dogs. In 1904 Jackson, Porter, and Quinby²⁴ made the first comprehensive survey of the literature, collecting 184 cases and adding 30 new ones obtained from various hospitals in Boston. Trotter⁵¹ in 1913 added six new cases of mesenteric thrombosis and collected in monographic form a total of 360 cases from the literature. He tabulated a mortality rate of 94 per cent, and a correct preoperative diagnosis in only four per cent of all cases.

Ross Loop³⁴ in 1921 reviewed in detail nine personal cases seen over a two-year period, which he declared presented a pathologic picture so char-

acteristic as to be unmistakable and a syndrome so uniform that it suggested a definite disease entity. His description of the gross pathology and symptomatology is by far the most vivid yet written. The same year Klein²⁷ made an extensive survey of the literature concerning the experimental work on mesenteric thrombosis.

Cokkinis⁴ published a monograph in 1926 and reported on experiments in which he found that the arterial collateral circulation was considerable and that the venous was of even greater volume.

Jerriault²⁷ successfully resected 19 feet of intestine for thrombosis of the superior mesenteric artery in 1929. Recently H. W. Meyer¹⁷ described the amazing case of a 20 year old soldier, operated on in a field hospital in whom it was necessary to resect all but 20 inches of the small intestine, and the right half of the colon for occlusion of the superior mesenteric artery, with complete recovery. This is a slightly more extensive resection than that reported by

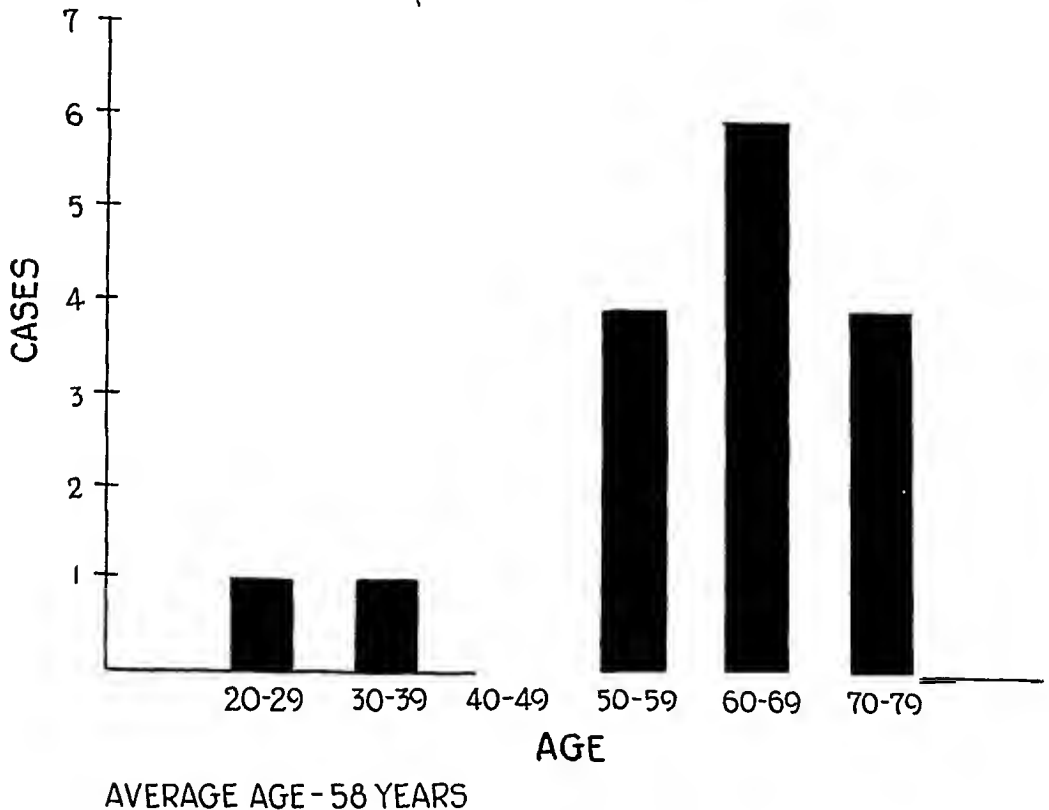


FIG. 3—Incidence of occurrence grouped in decades

Madding and McIntire³⁶ Grey Turner³² in 1937 reported a case in which he successfully performed a caesarian section and resected 10 feet of small bowel. That these extensive resections are feasible was shown experimentally on dogs by Flint¹⁸ in 1912.

INCIDENCE

"Primary" mesenteric vascular occlusion is a very uncommon disease, occurring in from .02 per cent³⁴ to .105 per cent⁴¹ of all surgical admissions. The

incidence at Touro Infirmary from 1938 to 1947 was 19 cases in 55,232 surgical admissions .038 per cent. It should be noted that, in most collections, cases due to local trauma and infection are included.

The disease is about twice as common in men as in women^{24, 30, 31}. In our series the proportion was 13 to 6. It occurs most often in the third to the sixth decade. In our own series the average age was 58 (Fig. 3), as compared to those of Brady² 44 years, Larson³⁰ 55.2 years, and Whittaker and Pember-ton⁷⁸ 43 to 45 years. However, it may occur in children, as one of us has previously observed and as has been reported by several authors²⁶. A number of cases have been observed in infants, the youngest being one month old^{26, 29, 33, 20}.

ETIOLOGY (Fig. 4)

Intestinal mesenteric occlusion may be either embolic or thrombotic, the former being more common (6 to 4 in this series).

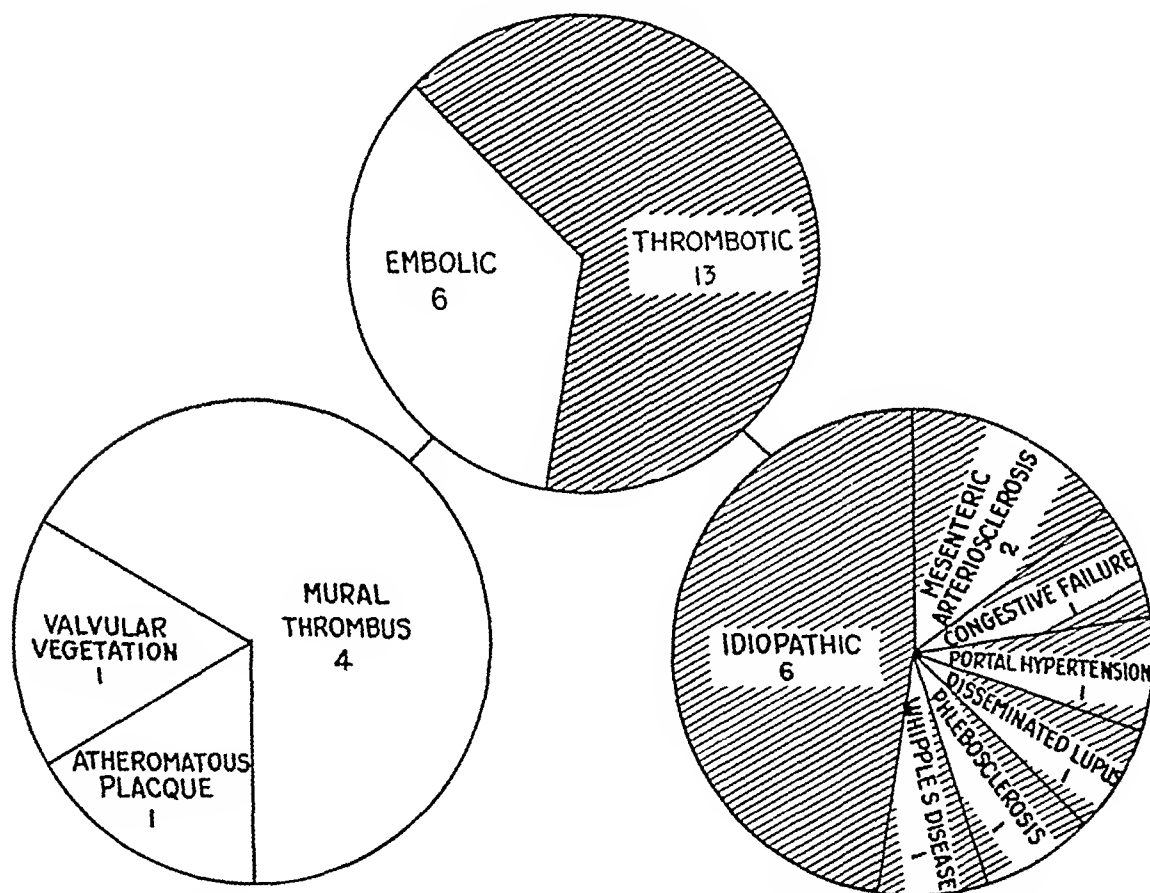


FIG. 4—Etiologic factors responsible for the embolic and thrombotic groups. The thrombotic group comprises arterial, venous, and combined categories.

The *emboli* may originate in the heart, the aorta, or the pulmonary veins⁷³. They may be fragments of thrombi, of aortic plaques, or of vegetations from the heart valves. Mural thrombi occurring in coronary occlusion and free clots formed in the heart chambers during severe arrhythmias or congestive heart failure are the most common sources. Such emboli are often large, and not infrequently block the superior mesenteric artery or one of its major branches (Fig. 5). Emboli from vegetations on the heart valves, on the other hand, are

usually small and often multiple. Numerous infarcts in other organs are frequently associated with either type.

Arterial thrombosis may result from diseases of the vessel walls, from infarction of the bowel due to venous occlusion, perhaps from alterations in the clotting mechanisms, and probably other causes. Among the vascular diseases reported to have caused it are Buerger's disease,²² Raynaud's disease,³¹ and mesenteric arteriosclerosis.⁵ Our series includes two cases of thrombotic occlusion of the superior mesenteric artery and one of a large branch of the same vessel, all due to advanced arteriosclerosis.



Fig 5—Embolus lodged in superior mesenteric artery

Venous occlusion is probably always due to thrombosis and its most common causes are infection and trauma, but these were excluded from this discussion, when the cause was apparent. This leaves as the usual causes of so-called primary venous thrombosis diseases of the vessel walls, slowing of the venous flow, damage to the vessel walls incident to arterial occlusion, and perhaps alterations in the clotting mechanism. Portal hypertension, due to cirrhosis of the liver, cavernomatous transformations of the portal vein, or congestive heart failure, is among the most common demonstrable causes. The vascular diseases, other than arteriosclerosis, that cause arterial occlusion may also cause venous thrombosis. To this group we add a case of disseminated lupus erythematosus which seems to be unique. It seems odd that whereas the vascular changes of this disease involve both arteries and veins, our pathologist found only venous thrombosis.

Combined arterial and venous thrombosis of the peripheral vessels is also a common type of mesenteric vascular occlusion. It seems probable that the process starts as a venous thrombosis in most instances and that the arteries are thrombosed secondarily, because patent arteries are frequently encountered in the involved area. The pathologist usually cannot determine where the process began. However, simultaneous arterial and venous thrombosis may occur in such diseases as thrombo-angitis obliterans.

Most instances of mesenteric *thrombosis* can be explained on the basis of one or another of the above mentioned causes but there remains a considerable number that must be listed as idiopathic. Even though we have excluded all cases in which infection of the intestinal wall was demonstrable, it seems probable that the "idiopathic" cases are due to some pathologic process in the bowel.

We have included one example due to Whipple's intestinal lipodystrophy⁵⁷ which seems to be unique

CLINICAL PICTURE

Whereas it is possible to classify most cases etiologically as arterial or venous, and as embolic or thrombotic, this is often impossible, clinically. There are only two distinct clinical types. The first is produced by sudden blockage of a major mesenteric artery and the second by any of the other forms of occlusion. The difference in behavior of these two groups is due to the fact that the former causes sudden complete infarction, whereas the latter causes a gradually increasing ischemia that may either subside or progress to complete infarction. Our collection includes seven of the first type and 12 of the second.

When the stage of infarction is reached, the picture is the same, no matter how it has developed,⁴⁷ and since all except two of the cases here reported had reached this stage no differentiation as to type was possible except on the bases of the history of a causative disease and the character of the onset.

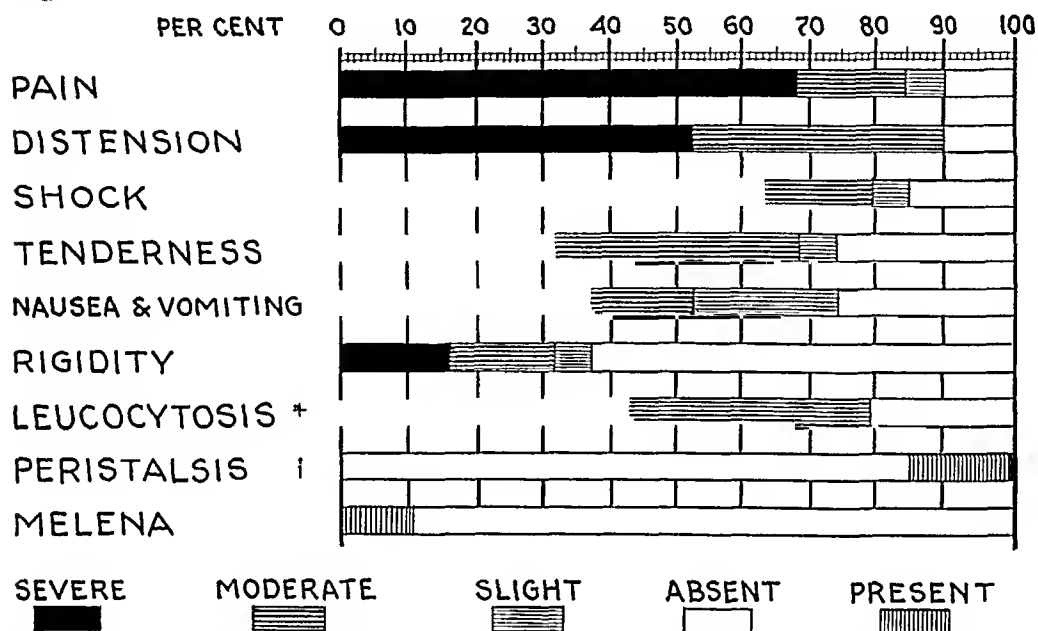
Since sudden occlusion of a major artery is almost always due to advanced cardiovascular disease, there is usually a recent history of such a condition, but occasionally it may be overlooked as in two cases of this series, and in the remarkable instance reported by H. W. Meyer.³⁷ Typically, individuals suffering from severe cardiac disease exhibit a dramatic transformation to the picture of a major abdominal catastrophe characterized by sudden severe abdominal pain, usually cramplike, severe nausea and vomiting, and profound shock. All signs of peristalsis soon disappear and, since these unfortunates usually die before peritonitis develops, rigidity is seldom seen. The temperature may be subnormal to slightly elevated. Leucocytosis, moderate to very high, is usually found. This striking onset is unfortunately frequently masked by the severity of the cardiovascular state, as we have twice observed.

The gradual development of intestinal ischemia that results from all other types of occlusion usually passes through three stages. First, a period of variable length, characterized by uncoordinated hyperperistalsis with colicky pains and nausea not unlike that following overindulgence in green apples, second, a period of intestinal paresis that produces the picture of partial intestinal obstruction, and, third, a period of intestinal strangulation with all of its consequences. The clinical state of the patient when first observed depends largely upon the stage of the pathological process, so that one must depend largely upon the history for diagnostic data. Histories taken by first year interns frequently cannot be depended upon for such data, so we have, to some degree, drawn upon our personal observations, as well as on the literature, to fill out the picture.

The prodromal period is characterized by (1) inconstant nagging abdominal pain, usually colicky, and located vaguely about the mid-abdomen, (2) nausea and vomiting, usually mild and frequently subsiding after a short time, (3) constipation or diarrhea, (4) moderate distention without rigidity. The picture changes gradually into one of intestinal obstruction with aggravation

of all features except diarrhea. Leucocytosis develops and is often very high. Peristalsis, which has been hyperactive, rapidly subsides. At any stage, up to and including this, spontaneous recovery may take place⁹ as one of us has observed twice previously, and as we suspect from the histories of two of the cases here reported. If recovery does not take place, the classical picture of intestinal strangulation develops, either gradually or with such dramatic suddenness that the prodromal period may be forgotten by both patient and family and can be recalled only by persistent questioning.

A more detailed discussion of individual symptoms and signs follows (Fig. 6).



* W B C NOT DONE IN 5 CASES 10-19 THOUSAND = MODERATE- OVER 20 THOUSAND = SEVERE

† RECORDED IN 7 CASES ONLY

FIG. 6—Pertinent clinical findings, tabulated in order of occurrence. *W B C not done in 5 cases 10-19 thousand—Moderate Over 20,000 = Severe †Recorded in 7 cases only

1 Pain is a constant symptom^{1, 14} being present in all patients whose state of consciousness permits its perception. At the onset it is often colicky and of mild to moderate severity, but later it usually becomes constant and very severe. In sudden occlusion of major arteries, it is severe from the onset if perceived at all. It is usually located vaguely about the mid- or lower abdomen, and there is no radiation. In our series it was severe in 13 cases, moderate in three, slight in one, and masked by a terminal cardiovascular state in two.

2 Tenderness is less constant but is distributed as is the pain. It is usually not severe until peritonitis develops. In our series it was severe in six, moderate in seven, slight in one, and absent in five.

3 Rigidity does not occur until peritonitis develops and in extremely ill patients may not be found even then.^{11, 8}

4 Distention develops gradually and is marked only in the late stages of the process.²⁴ In this series it was marked in ten, moderate in seven, and absent in two. It is interesting that the last mentioned two were cases of massive arterial occlusion. Perhaps death occurred so soon after this developed that there was insufficient time for the development of distention.

5 Shock is present at the onset only in sudden massive infarction but develops in almost all if not all cases where extensive gangrene occurs.¹⁷ It was present therefore in most of our cases (16), before operation or death. It was reported as severe in 12, moderate in three, mild in one, and absent in three.

It was usually impossible to relieve the shock in these patients, even though large amounts of blood and other fluids were given.

6 Nausea and vomiting are common but not usually severe. They were severe in seven cases, moderate in seven, and absent in five of our series.

Hematemesis is said to be common¹¹ but it occurred in only one of the cases here reported, and in that one it was due to esophageal varices in a case of portal hypertension and occurred before the onset of the mesenteric thrombosis.

7 Peristalsis is undoubtedly active at the onset but it usually ceases early, so was often absent at the time of admission to the hospital. No mention was made of it in 12 of our cases, which we consider a shameful neglect of a valuable diagnostic aid. No doubt this examination was made more often and not recorded as we are sure was the case in two of our own patients. In the seven cases in which auscultation of the abdomen was mentioned, peristalsis was heard in only one.

8 Melena is said to be frequent and of great diagnostic importance,^{1, 24, 41, 58} but it occurred in only two of our cases, and in one of these it occurred before the onset of the thrombosis and from another cause. In view of the fact that gangrenous bowel always contains blood, it is surprising that melena was so infrequent. When observed, it must be considered an important diagnostic sign, and a rectal examination should be made in all suspected cases.

9 *Temperature* Subnormal temperature has been noted by several observers^{8, 14, 34} but was not a feature of the cases here reported. In those without gross evidence of peritonitis the temperature averaged from 99 to 101.

10 *Leucocytosis* Unlike other types of intestinal obstruction, that caused by mesenteric vascular occlusion usually causes a high leucocytosis. In eleven of our cases it ranged from 14,000 to 30,000 total leucocytes, and from 85 per cent to 95 per cent polymorphonuclears. In five there was no record of a blood count, and in three normal values were observed. A high leucocytosis when found is a valuable point in differential diagnosis.¹⁷

11 After gangrene has developed, an indefinite doughy mass is often palpable. This has frequently been reported,^{14, 27} and we have ourselves observed it in four of our own cases, all of which are included in this series. Since such a mass was noted in the record of only three cases, we are confirmed in our belief that others beside ourselves have been negligent in recording all of their find-

ings In one of our personal cases, the mass was felt only after a spinal anesthetic was administered, and was a valuable finding in determining the site of the incision

12 Constipation is the rule after the onset of the obstructive phase of the disease, but bloody diarrhea has been reported^{8, 14} Only four of our cases had a history of recent diarrhea and only two had diarrhea after hospitalization One of the latter was the case of Whipple's disease, in which diarrhea is a constant symptom

13 Jaundice has not previously been reported In this series it occurred in four, three of which were our own One survived, so the cause could not be determined, but he showed evidence of hepatitis, including a 2+ cephalin flocculation, a direct Van den Bergh reaction, and an icterus index of 100. one had marked cirrhosis of the liver, and one showed at autopsy severe fatty metamorphosis, and central lobular degeneration of the liver cells The jaundice was hepatogenous in type in all four and one may speculate as to whether hepatitis contributed to the causation of the thrombosis or whether it resulted from the absorption of toxic products from the gangrenous bowel

14 *Roentgen-ray Findings*—Roentgen-ray examination of the abdomen was made in only nine cases, in two of which a tentative diagnosis of mesenteric thrombosis was made by Dr Meyer Teitelbaum, who has since reviewed all of the films and compared them with his special file on intestinal obstruction He states that, "Analysis of the films of these patients indicates that in no case were they absolutely normal The deviations do not, however, follow any fixed pattern nor can they be correlated with the nature, site, extent, or duration of the vascular occlusion in such fashion as to permit a definite preoperative diagnosis" Having thus satisfied his craving for meticulous accuracy, he makes it clear that (1) ileus of varying grade was present in all cases, (2) the colon, contrary to what is usually seen in mechanical obstruction, usually contained a normal amount of feces and gas, and (3) while one group showed findings similar to those seen in gastroenteritis or in partial obstruction, the other simulates mechanical obstruction, especially with strangulation and peritonitis Such findings, while admittedly not diagnostic, should urge the surgeon toward early exploration

DIAGNOSIS

The diagnosis of this disease can usually be made or suspected if it is given consideration When an acute abdominal crisis is encountered, several points should direct attention to it

- 1 A history or physical findings of any of the before-mentioned predisposing causes

- 2 The character of the onset, which is in general of two types

- a A sudden transformation from a picture of advanced cardiovascular disease to one of an acute abdominal catastrophe

- b A gradual transition from a mild "colic", with or without diarrhea,

to a picture of partial intestinal obstruction, and finally to one of intestinal strangulation

3 The early diminution or disappearance of peristalsis in a case in which, after due consideration of the common causes of "the acute abdomen", intestinal obstruction seems the most probable one

4 The appearance of a high leucocytosis in such a case before peritonitis develops

5 Roentgen-ray evidence of ileus without evidence of evacuation of the colon or, as sometimes occurs, with diffuse dilatation of the entire small bowel and the right half¹⁶ or all of the colon We also feel that roentgen-ray evidence of free fluid in the peritoneal cavity before peritonitis develops is a significant sign

6 Bloody stools or blood in the rectum if not otherwise accounted for

OPERATIVE FINDINGS

A proper evaluation of the evidence will usually lead to exploration if the condition of the patient permits Even then the diagnosis may be missed in the early stages, as we believe occurred in two cases in this series, if one fails to bear in mind the gross pathologic picture so graphically described by Loop

When the abdomen¹⁵ is opened, a copious amount of peritoneal fluid escapes It is transparent, sticky, amber, or, more often, blood-tinged, odorless, and without coagulated lymph All visible intestine may appear normal, though slightly distended The diseased portion may be entirely overlooked unless sought for deep in the pelvis The cyanosed, plum-colored, soggy, edematous intestine with glistening peritoneum free from exudate or adhesions, its lumen relaxed but not greatly distended, lies inert within the abdominal cavity, held down by the weight of the fluid within its lumen It contains little gas The mesentery is a thick doughy mass dragging down over the brim of the pelvis as though adherent Thrombosed vessels may often be seen and felt This description taken almost verbatim from Loop applies to the stage before gangrene has developed From earlier experience we can confirm it and add the observation that the bowel distal to the involved segment is usually as much distended as is that proximal to it This is also true after complete infarction It is evident that the paralytic ileus extends both proximal and distal to the ischemic segment

Our recent experience includes no early cases Late in the disease when the abdomen is opened, a large amount of turbid, bloody, fetid fluid escapes The involved bowel now lies in the abdominal cavity proper, presumably having been dragged up from the pelvis by the shortening of the mesentery that results from edema and hemorrhagic infiltration It is plum to chocolate-colored, with a greenish iridescent sheen, and lies heavily deep in the cavity If the gangrenous segment is small, it may be completely covered by flaccid distended loops of viable bowel, but if it is extensive, it may fill the entire field—an appalling sight Small wonder that many such cases have been

abandoned as hopeless. A well-marked line of demarcation may be seen occasionally, but usually there is a slow gradation from black to purple to red to pink. The bowel is rounded but not usually 'greatly distended'. It contains much bloody fluid but little gas, presumably because the thick leathery wall resists distention. On one previous occasion we have seen a markedly distended bowel in a case of sudden massive occlusion of the superior mesenteric artery. In this instance the infarction had been so abrupt that the infiltration was minimal.

The mesentery is thickened, edematous, and hemorrhagic. The major vessels may be felt as thick cords, but are difficult to see. The small veins stand out as reddish black lines in the pale yellow, red-splotted mesentery. When clamps are applied, they cut through the swollen tissue as if it were only cheese and black worm-like clots are extruded from the vessels.

Very late in the disease, if the patient survives long enough, peritonitis develops, whether or not perforation occurs.

PROGNOSIS

Although the fourth case of mesenteric vascular occlusion reported to have been operated upon for this disease recovered,¹⁴ 24 successful resections had been reported by 1921,²⁷ and a recovery rate of 68% following surgery was estimated by J. Meyer³⁸ in 1931, results are actually still very poor. The mortality reported by Meyer comes from a survey of the literature which abounds in successful case reports, and such reports are notoriously misleading. Larger consecutive series are more dependable. Whitaker and Pember-ton record a mortality rate of 84% in 19 operative cases. One of these cases was a volvulus which does not properly belong in this category. Douglas¹⁰ had four recoveries in 11 patients he operated on, and Moore four in eight operated upon. We report only one recovery in 19 cases, but only eight were operated on (Table I).

TREATMENT

The mortality in our series is so high that it does not seem to encourage surgical treatment but there are several factors that favor some degree of optimism.

- 1 Seven of these patients were practically moribund from cardiovascular disease when the mesenteric occlusion occurred as a terminal event. They were, of course, hopeless and should not influence our opinion as to the value of surgery in patients who are in reasonably good general condition.

- 2 The most extensive resection in this series (Fig 7) and numerous similar or more extensive ones reported have been successful. Among these the amazing cases of Meyer and of Madding and McIntire, each of whom resected all of the small bowel, except two to four feet, and the right half of the colon, and that of Grey-Turner, who resected ten feet of small bowel and performed a Caesarian section at the same time, are notable. It is evident that if the patient is otherwise reasonably sound, resection is worth trying no matter how extensive the lesion.



FIG 7—A Massive gangrene of jejunum and ileum Twelve feet resected with survival of patient

3 Many surgeons, including ourselves, have formerly believed that mesenteric thrombosis was almost inevitably progressive and would therefore spread to involve the anastomosis if resection were done. Many case reports and our own experience show that this is not true. Three of our cases survived the operation for eight or more days. The anastomosis healed and functioned in all three. One developed another area of thrombosis with gangrene but at a distance from the site of the anastomosis.

Due to the early experience of one of us (J.D.R.) with three cases of mesenteric thrombosis, short of infarction that were treated by enterostomy, with two recoveries, and to the high mortality of resection, we had formerly believed that such cases were best treated conservatively, a view expressed by Ross.⁴⁸ We now believe that this is a dangerous practice, for most of such cases will probably progress to gangrene if the ischemic segment is not removed with a liberal margin of normal bowel. If resection is done at this stage, the mortality should be quite low.

The use of anticoagulants has not yet had a fair trial in this disease. A few successes have been reported,^{19, 42, 35} but not enough to be of real significance. Theoretically, they should be of great value in both prevention and treatment. (1) The formation of clots in the heart may be prevented, thus lessening the danger of embolism to the mesenteric as well as to other vessels.⁴⁰ (2) mesenteric thrombosis short of infarction may be arrested before fatal ischemia develops and (3) the spread or recurrence of mesenteric



FIG 7—B Contrast study of gastro-intestinal tract done three and one-half weeks after operation

thrombosis after resection may be prevented³³ Our own experience has been somewhat discouraging Three of our patients survived long enough to permit a trial One had recently suffered massive hemorrhage from esophageal varices, so we dared not use anticoagulants Heparin was tried in the other two, but one developed melena of severe grade on two occasions, and the other bled into and around the operative wound Perhaps our control of clotting time was not accurate Certainly we believe that anticoagulants have value and should have a thorough trial, but wide resection of the diseased bowel is necessary when infarction has occurred, and we believe that it is desirable in all cases suitable for operation

CONCLUSIONS

- 1 The mortality of mesenteric vascular occlusion is extremely high because (a) many patients are in extremis from cardiovascular disease when it

occurs and (b) in most others diagnosis and treatment are too long delayed. The first cause is unavoidable, but the second frequently is not.

2 Pathologically, mesenteric vascular occlusion can be classified as embolic or thrombotic and as arterial, venous, or combined, but no such differentiation can be made clinically. Sudden complete occlusion of major mesenteric vessels produces a recognizably different picture, but all other mechanisms produce essentially the same syndrome.

3 Features that aid in diagnosis are (a) a history of a known predisposing cause, (b) the character of the onset, (c) the early disappearance of peristalsis in a case of suspected intestinal obstruction, (d) the occurrence of a high leucocytosis, in such a case without evidence of peritonitis, (e) the development of shock when all other evidence points toward partial obstruction.

4 The treatment for all types of the disease should be the same because the effect on the bowel is the same and the ischemia usually progresses to infarction. Radical resection of the bowel is essential when gangrene has developed, and is, we believe, advisable in all cases. Anticoagulant therapy may prevent mesenteric vascular occlusion and may be of value in postoperative treatment, but cannot, at this time, be recommended as definitive treatment.

NOTE—We would like to express our appreciation of the invaluable assistance of Dr Harvey Colvin, Head of the Department of Pathology at Touro Infirmary, and of Dr Meyer Teitelbaum, Head of the Touro Infirmary's Department of Radiology. Dr Colvin made a complete review of all the pathologic material in this series, and his interpretations formed the basis of our analysis. Dr Teitelbaum compared all the roentgenograms with his special file on intestinal obstruction and made a searching analysis of them for us.

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DISCUSSION—Dr L H STRUG, New Orleans I would like to take this opportunity to show some interesting features of several of our cases (slides)

The first slide shows a schematic drawing of the small and large bowel, showing the approximate amount of small bowel involved in the infarction and extent of resection. Eleven feet of jejunum and ileum were involved as a result of the mesenteric thrombosis, and twelve feet of small bowel was resected, with survival. The next slide shows the gangrenous bowel, with the gradation on each end to normal appearing bowel.

The next slide is taken from a gastro-intestinal x-ray series which was done approximately four weeks following surgery, and shows the remaining small bowel, which is estimated to be between four and six feet in length.

The next slide is from our case of mesenteric thrombosis, in which intestinal lipodystrophy (Whipple's disease) is held to be the causative factor. This slide shows the greatly magnified intestinal villi, which is considerably enlarged due to numerous fat deposits and large number of foam cells, characteristic of this disease. Next is another microscopic section showing extrinsic compression of a venule by the large foam cells and fat deposits.

This slide is from our case of disseminated lupus erythematosus, which shows the characteristic hyaline degeneration of the wall of the arterioles. This section is taken from the stomach wall. Next is shown typical arteriolar involvement in the periadrenal vessels. The next slide, from a section of the intestinal wall, shows normal mucosa, ulceration and involvement of the venules with thrombosis. The occurrence of this pathologic process in the stomach and small bowel is unusual.

The next two slides are from a case which Dr Lucian Landry kindly allowed us to use in our series. The first is a schematic drawing of the large and small bowel, which attempts to depict the three episodes of mesenteric vascular occlusion, with the terminal one resulting in infarction, perforation, peritonitis and death. The second slide shows the three episodes of mesenteric venous occlusion. The oldest and first episode is to your right, showing a venous thrombosis, which is old, and organized, with some evidence of

recanalization, the middle section shows a somewhat more recent venous thrombosis, with some organization, and the one to the far left shows an extremely recent venous thrombosis, with a laminated thrombus and no organization whatsoever

The final slide is a table showing the extent of involvement of our 19 cases, one case having infarction in the mesentery alone, two having perforation and peritonitis with minimal infarction, and the extent of resection in the four cases in which this was done

DR JAMES D RIVES, New Orleans (closing) The cases we have reported did not include an example of mesenteric thrombosis due to a blood dyscrasia, nor have we found an authentic case in the literature Dr George Curtis has just reported to me a case following splenectomy for thrombocytopenic purpura It is probable that it is a case of thrombosis of the superior mesenteric vein resulting from the tremendous increase in platelets that commonly follow splenectomy for thrombocytopenic purpura However, it must be remembered that thrombosis of the splenic vein frequently occurs following splenectomy and that it may spread to involve the portal and mesenteric veins Doctor Curtis' case may therefore have been the result of the splenectomy rather than of purpura *per se*

LYMPHANGIOMA OF THE MESENTERY*

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BENIGN TUMORS OF THE MESENTERY occur rarely and lymphangiomas in this location are especially unusual. According to Bonaquehay's¹ account, Benevieni, in 1507, was the first to observe a cystic tumor of the mesentery, and Carson,² in 1890, made the first American report of a chyle cyst of the mesentery. Geister³ wrote in 1939, there were approximately 500 cases of chyle cysts reported in the literature. Murbach, Lewison and Diebert⁴ stated that the great majority of the reported abdominal lymphangiomas have involved the omentum and that the retroperitoneal and mesenteric types have occurred much less frequently.

A lymphangioma is usually described as a neoplasm consisting largely of endothelial lined spaces containing lymph. Wegner's⁵ original classification of lymphangiomas is generally accepted although transition types are sometimes seen.

SIMPLE LYMPHANGIOMA

A circumscribed swelling composed of dilated lymph vessels in a very cellular connective tissue stroma. This type is usually seen in infants and children, involving the skin and subcutaneous tissues of the face and neck.

CAVERNOUS LYMPHANGIOMA

A spongy tumor, composed of dilated lymph vessels, in an actively growing lymphoid stroma. This form is seen more often about the face, tongue, neck, mesentery and the retroperitoneal regions.

CYSTIC LYMPHANGIOMA

Cystic lymph spaces, usually endothelial lined, in a lymphoid stroma. Cystic lymphangiomas may be seen in the neck, the supra or infraclavicular regions, the axillae, the retroperitoneal space, the mesentery and the inguinal regions.

ETIOLOGY

Most writers favor the opinion that lymphangiomas arise from embryonic rests of lymphatic tissue. As pointed out by Singleton,⁶ wherever these centers exist congenitally, such tumors are possible. This is substantiated by the preponderance of the tumors in the region of the jugular, subclavian, axillary, iliac, femoral and mesenteric lymph sacs.

Several investigators felt that lymph stasis following chronic lymphadenitis might be an important factor in the etiology of lymphangiomas. However, Ewing⁷ was able to demonstrate free communication between the afferent and

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Wednesday, December 10, 1947.

effluent lymph vessels in several lymphangiomas and concluded that stasis could not have been an important etiologic factor

SYMPTOMS

The tumor may be asymptomatic and incidentally found at the time of an abdominal operation or at necropsy. If the lesion is large enough, the patient may notice an abdominal tumor, or there may be a feeling of tension due to increase in the size of the abdomen. Occasionally a patient complains of abdominal pain which is usually intermittent, aching, dull, and rather constant in position.

DIAGNOSIS

An exact diagnosis is frequently impossible but careful physical examination and roentgenographic studies may inform the examiner that the adjacent viscera are normal and assist in the localization of the tumor. If the mass is on the right side, one must exclude enlargements and tumors of the gallbladder, duodenum, adrenals, pancreas, liver and right kidney. On the left side, lesions of the stomach, spleen, left adrenal and left kidney must be considered. Pneumoperitoneum, followed by roentgen examinations, may assist in the differential diagnosis. However, frequently exploratory celiotomy must be performed before an accurate diagnosis of the abdominal tumor can be made.

TREATMENT

Excision is the treatment of choice if it is mechanically feasible. According to Roller,⁸ simple enucleation of the cyst has been associated with a mortality of 9 per cent. When resection of intestine must also be done, the mortality is given as 25 per cent to 30 per cent. Aspiration of part, or all of the cyst contents may facilitate the excision. If excision is associated with too great a risk, or mechanically is not feasible, marsupialization may be done. Healing usually occurs in a few weeks following marsupialization. Roller⁸ states that marsupialization has a mortality rate of 16 per cent. However, it should be recalled that marsupialization is usually done in cases where excision is impossible or impractical.

We wish to present a case of a rather large lymphangioma of the mesentery of the jejunum.

REPORT OF CASE

A white male, aged four years, was presented at the Clinic for examination on March 14, 1947, because of abdominal pain of three days duration and history of increasing size of the abdomen since infancy. The family history was essentially normal. Past history revealed fairly frequent respiratory infections and an otitis media two years previously. Tonsillectomy had been performed in 1945.

The parents of the child stated that there had been some enlargement of the patient's abdomen since birth but that his health had otherwise been essentially normal until the onset of the episode prior to his admission to the Clinic. Approximately three days prior to his registration the child developed abdominal pain in the epigastrium. This discomfort was mild, did not stop his playing and was intermittent in type. The local physician examined the boy, told the parents there was fluid present in the abdomen and referred him

LYMPHANGIOMA OF THE MESENTERY

to the Clinic. There were no other symptoms. His appetite was good and his weight was normal for his age and height.

Physical examination revealed a well developed and nourished white male of four years who did not appear to be ill. Weight 35 pounds, temperature 100 degrees rectally, pulse 112, respiration 22, blood pressure 105/70.

There was no palpable lymphadenopathy. Examination of the head and neck was normal. There were no demonstrable abnormalities of the heart and lungs. The abdomen was distended and the umbilicus was everted. There was a suggestion of a palpable mass in the right upper quadrant, the right lower quadrant and the left upper quadrant of the abdomen. One could not be sure if these were lobulations of one tumor or separate

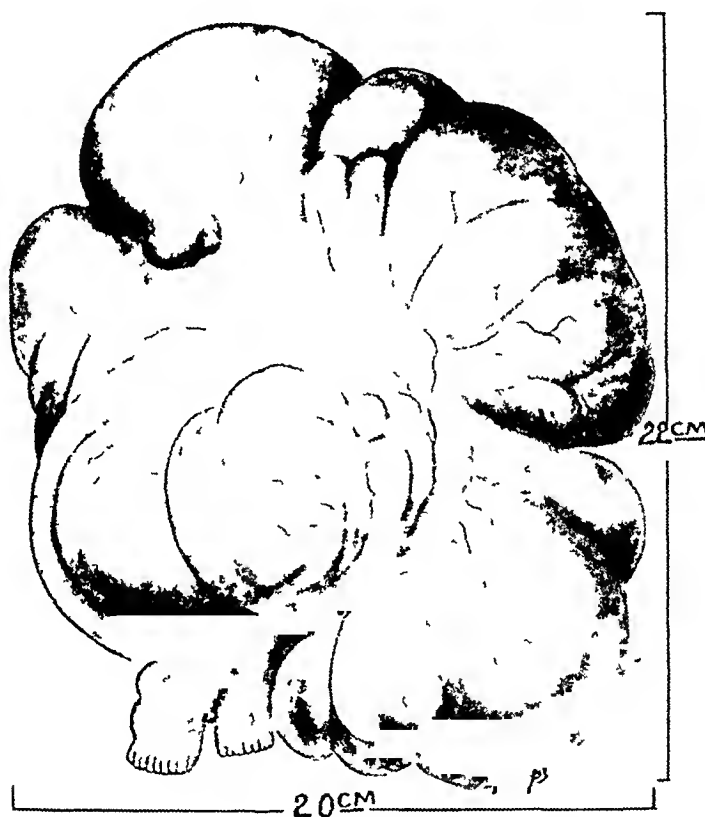


FIG 1—Drawing of the tumor, showing the large multicystic lymphangioma of the mesentery of the jejunum

tumors. There was dullness to percussion over these areas but no fluid wave was elicited. The largest mass was thought to be five or six inches in diameter and none of the areas were tender. Examinations of the rectum and genitalia were normal.

Laboratory reports—Urinalysis normal. Hematology March 14, 1947, hemoglobin 10.5 Gm per 100 cc of blood. Erythrocytes 4,520,000. Leucocytes 9,700. Differential: neutrophils, 50%; Lymphocytes 45%; Monocytes, 1%; Eosinophiles, 4%. Hematology March 18, 1947, hemoglobin 13.5 Gm per 100 cc of blood. Erythrocytes 4,710,000. Leucocytes 7,250. Differential: neutrophils, 75%; Lymphocytes, 25%. Sedimentation rate 20 mm per hour. Blood morphology: moderate hypochromia, otherwise normal smears. Blood chemistry: blood urea, 23 milligrams per 100 cc of blood.

Roentgenogram of the chest was negative. A flat plate roentgenogram of the abdomen revealed an indefinitely outlined soft tissue mass in the abdomen with questionable fluid present. The intravenous pyelogram showed normal function of both kidneys. The right

ureter was kinked at the level of the fourth lumbar vertebrae, apparently induced by an extrinsic mass

The patient's parents were advised that the boy probably had mesenteric or omental cysts and on March 17, 1947, exploratory celiotomy was performed through an upper transverse abdominal incision. There was a large mass approximately ten inches in diameter and five pounds in weight which almost filled the abdomen. No viscera were visible anterior to it.

The tumor was delivered into the wound and it was apparent that it consisted of numerous large cystic masses in the mesentery of the jejunum. The afferent and efferent loops of jejunum entered the neoplasm at opposite ends and the intervening 25 cm of jejunum were densely incorporated in the tumor. It was impossible to remove the

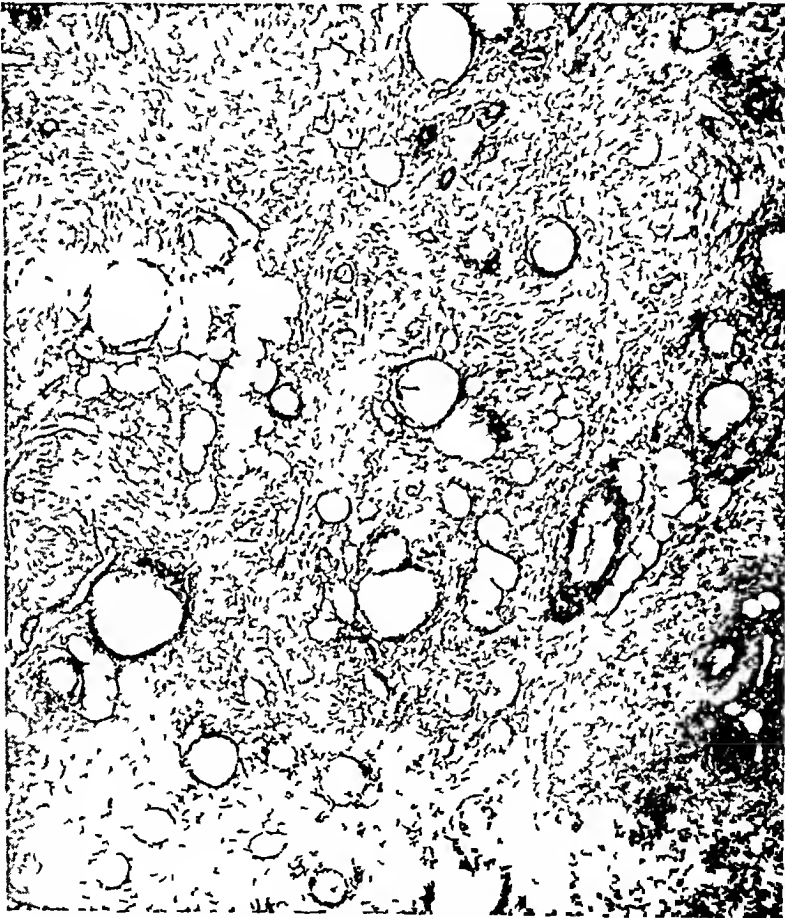


FIG 2—Higher power microscopic appearance, demonstrating the numerous, diffuse lymph spaces located in a fibrous stroma containing many lymphocytes

growth without resecting a segment of the jejunum. Therefore, a segment of the jejunum was resected and the mass removed. The ends of the jejunum were closed and a side to side jejunojejunostomy performed. After removal of the tumor, examination of the remainder of the abdomen did not reveal any other tumors or gross abnormalities except rather diffuse mesenteric lymphadenitis.

The pathologist reported the tumor measured 22 x 20 x 7 cm and weighed 2033 Gm. The relative large size of the tumor is better appreciated by realizing it constituted approximately one-seventh of the boy's weight. The lesion was multicystic and filled with

A thick milky fluid. Hemorrhage had occurred into some of the cystic spaces, imparting a reddish color to these areas. There was no evidence of infiltration into the bowel by the tumor. Microscopic sections revealed spaces lined with endothelium and a rather large amount of lymphoid tissue in the connective stroma. Laboratory studies of the contents of the lymphangioma revealed a milky alkaline fluid with specific gravity of 1.020. Cholesterol, 88 mg per 100 cc. Cell count of the fluid showed lymphocytes, 84%, neutrophils, 14%, eosinophils, 2%. Erythrocytes 13,600. Leukocytes 2,300. Cultures of the fluid did not reveal any growth after 48 hours.

The patient's postoperative convalescence was entirely uncomplicated and he was dismissed from the hospital on the thirteenth day following the operation. Observation three months after surgery revealed his general condition to be good and roentgenograms showed a normally functioning jejunojejunostomy. There was no evidence of recurrence of the lymphangioma.

CONCLUSIONS

- 1 Tumors of the mesentery should be given consideration in the differential diagnosis of abdominal neoplasms.
- 2 Benign tumors of the mesentery occur rarely and lymphangiomas are especially unusual.
- 3 Most lymphangiomas probably begin in embryonic rests of lymphoid tissue.
- 4 Careful physical examination and roentgenography are the greatest aids in diagnosis.
- 5 The treatment of choice is excision of the lymphangioma. When this is not feasible, marsupialization may be done.
- 6 A case of a large lymphangioma of the mesentery of the jejunum is presented. The tumor, including a segment of the jejunum, was removed and a jejunojejunostomy performed, with an uncomplicated recovery.

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ENTEROGENOUS CYSTS OF THE DUODENUM*

Report of a Case That Is Unusual If Not Unique

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ENTEROGENOUS CYSTS are said to be fetal inclusions and may be found anywhere in the intestinal canal. They are related to the diverticula, as described by Meckel and others. The cyst may be likened to a diverticulum



FIG 1—X-ray showing the blocking of the pylorus

which has been cut off, so to speak, with no open end in the lumen of the intestine. Thus it becomes a nidus of secreting cells buried within the wall of the intestine. Structurally it is composed of the coats of the intestine greatly thinned out. It is submerged in the bowel wall and is filled with a clear or

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Wednesday, December 10, 1947

yellowish fluid. It manifests its presence by obstructive symptoms and is seldom if ever diagnosed before operation.

Enterogenous cysts of the duodenum carry a high operative mortality, said to be 50 per cent. This is due to two factors: first, the very tender age of these patients and the weak and depleted conditions in which they come for treatment; secondly, the location of the lesion close to the entrance of the ducts from the liver and pancreas. The ideal operation, of course, is complete excision. Diversion into the lumen of the bowel and drainage of the cyst have



FIG 2—Showing tumor distending the duodenum

been tried. One operator by-passed the lesion successfully by doing a gastroenterostomy.

A brief summary of the cases of this condition reported to date follows. Gardner and Hart¹ of Durham, North Carolina, reported a successful operation on a girl of 15 years. In a careful review of the literature up to that time, they found only six other cases—all infants. Their case has remained the oldest reported up to the present. Shallow, Wagner, Jr., and Manges² of Philadelphia reviewed the literature up to April, 1947, and were able to find

but 13 cases (including the seven mentioned above) To these Dr Shallow added his case, making a total of 14 altogether It is significant that of these 14 cases, ten were between birth and four months of age, and the oldest was 15 years My own case, at the age of 69, must therefore be regarded as unusual if not unique

CASE REPORT

Mrs E R R, age 69 years, married, with three children She was strong, very athletic, and gives no history of any digestive trouble in early life

About 24 years ago she had some digestive disorder and took soda for its relief She



FIG 3—Showing incision made in the stomach and exposure of the tumor

later consulted a physician who obtained a negative cholecystogram and advised a gastro-intestinal roentgenogram Later her digestive symptoms returned and a gastro-intestinal roentgenographic study was made June 18, 1924 The same roentgenologist who examined the gallbladder reported a large penetrating ulcer of the lesser curvature of the stomach several inches above the pylorus The duodenum was negative

She was put on an ulcer diet and recovered A follow-up of the roentgenogram showed the ulcer healed She got along with little or no discomfort until the early spring of this year, 1947, when she again had epigastric pain, discomfort and regurgitation of partially digested food On March 19, 1947, a gastro-intestinal roentgenographic study was made The report is as follows "Stomach There is a good deal of spasm of the pyloric antrum, and the duodenal cap shows a gross central deformity with more or less smooth outline,

the barium being displaced, giving the cap a ring-like appearance. We believe this to be due to a nonmalignant tumor of the duodenal cap."

She was admitted to St. Luke's Hospital, April 10, 1947. The only indications for operation were the history and roentgen-ray report. The physical examination was negative. There was no tumor mass nor tenderness.

On April 11th under general anesthesia an upper right rectus incision was made. The gallbladder was quite normal. The stomach was normal in size and position. In the pylorus and first portion of the duodenum could be felt a tumor, soft and semi-elastic, that could be pushed through the pylorus. A transverse incision was made just proximal to

the pyloric ring, into the stomach. Now it was seen not to be a pedunculated tumor or polyp, but a semi-elastic tumor or cyst within the anterior wall of the duodenum and definitely reducing the size of the pyloric lumen. By manipulating the tumor with a finger inside the pylorus we slipped the outer coats of the stomach down and then made an incision down the tumor wall and dissected it from its bed in the wall of the duodenum. We did not open the lumen of the bowel but preserved its mucosa intact.

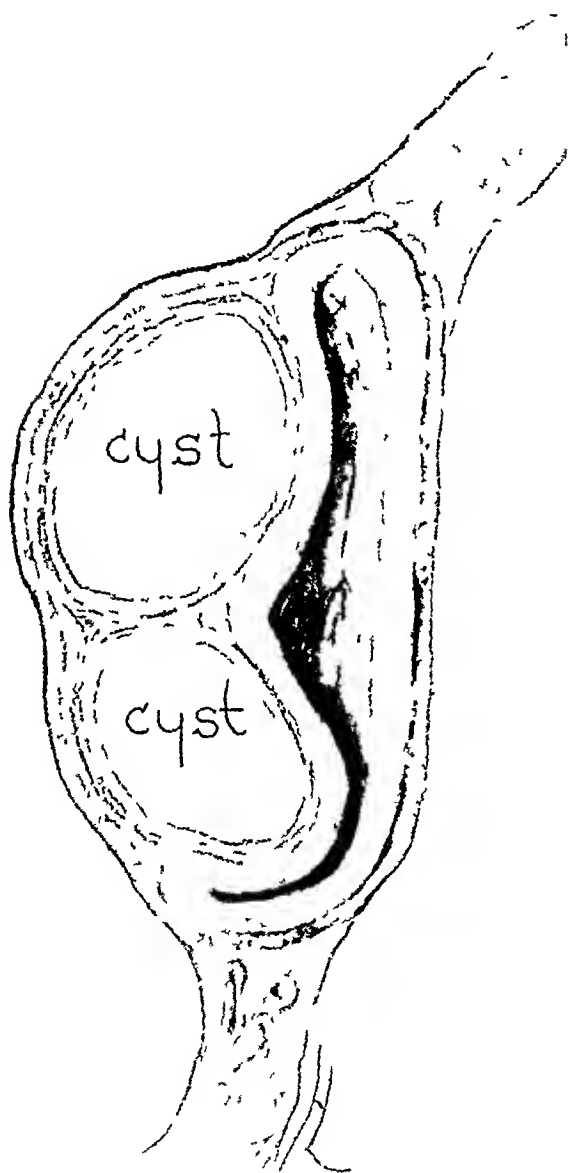
The tumor was about three inches in length by one inch in diameter, and consisted of two thin-walled cysts, in tandem, like a dumbbell. They dissected out easily with little bleeding. The wound in the duodenal wall was closed with chromic gut to abolish the dead space. Next the incision in the stomach was closed in the usual way, using black silk in the outer layer. The postoperative course was uneventful and her convalescence was without incident.

SUMMARY

Enterogenous cyst of the duodenum is a rare condition. This case is apparently unique because of the patient's age, 69 years. The condition is generally regarded as congenital and yet there is no history in this instance of any gastric trouble in early life. In fact, we have roentgenologic evidence that there

FIG 4—Showing the two cysts in tandem and how nearly they have closed the duodenum.

was no tumor present 23 years ago when the patient was 44 years old. The symptoms for which she finally sought relief were manifest in the spring of 1947 when the obstructive symptoms began. For a benign tumor to develop in the stomach of a woman 69 years of age, occurring without bleeding and without loss of weight, was of itself unusual. If the origin was congenital why did it



wait 68 years to manifest its presence and what was the factor that activated its growth? These questions I hope may be solved by some listener or reader more versatile than I

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DISCUSSION—DR CHARLES W MAYO, Rochester, Minn I apologize for rising to discuss the subject of lymphangioma of the mesentery inasmuch as I am one of the great majority of surgeons who have never seen or dealt with such a condition My excuse is that I want to cite the experience at the Mayo Clinic regarding these cysts

Ewing has classified cysts of the mesentery under four heads (1) lymphatic or chylous, (2) enteric, (3) urogenital, and (4) dermoid or teratoid cysts

At the Mayo Clinic, cysts of the mesentery have been observed in 175 cases, in only seven of which the cysts were lymphangiomata I should like to call attention to one such case reported by Beahrs and Judd* in July of this year, in which the operation consisted of marsupialization and drainage The patient was a woman 37 years of age, who had a four months' history of difficulty related to the condition At operation a large tumor was found, which had markedly displaced the other organs in the region A total amount of about 12 liters of chyle was removed from the multiloculated cyst

There are a few points of importance regarding lymphangioma of the mesentery These cysts are multiloculated and one must try to break down the various septa at the time of drainage One must anticipate infection at the time of drainage and for that reason must administer streptomycin or penicillin after the operation and must place in the cavity some sclerosing agent to help obliterate the sac Another point is that drainage should be continued for at least a week or ten days after one thinks the drains should be removed

I was interested in the report of the Doctors Brindley My idea of a good surgeon is the one who considers before operation what might be found and then deals with it properly at the time of operation, as was done in the case reported by the Doctors Brindley

DR DERYL HART, Durham, N C I thought it might be of interest to mention the case of an enterogenous cyst of the duodenum which Doctor Gardner and I saw in 1930 or 1931 This was a child of 15 with a history of recurring attacks of vomiting There was a tumor which, at times, was quite prominent beneath the costal margin on the right, while at other times it would shrink until barely palpable, or would disappear entirely When it disappeared she was relieved of her symptoms, when it reappeared vomiting recurred At operation we found a mass which appeared to be continuous with the stomach, and occupied the region of the first portion of the duodenum and had every appearance of a tensely distended duodenum The site of the pylorus could not be determined except by the location of the pyloric vessels The duodenum seemed to be as large as the lower portion of the stomach, was tensely filled, could not be emptied by pressure, and it was presumed that a cystic tumor was present beneath the musculature The position of the duodenal lumen could not be determined, since the musculature and vessels of the duodenum surrounded the entire mass The diagnosis had not been made before operation, but the suggestion had been made that it might be a cyst of the common bile duct

* Beahrs, Oliver H, and Edward S Judd, Jr Chylangiomas of the Abdomen, Report of Case Proc Staff Meet, Mayo Clin, 22 297-304, 1947

In order to determine the relationship of the lumen of the duodenum to this cystic mass an opening was made into the stomach above the pylorus. It was found to be superior and anterior to the tumor. The cyst was so large and so intimately attached to the pancreas that we felt its removal would be too hazardous. As an alternative we anastomosed the cyst to the duodenum, thus converting it into a diverticulum. We hoped that, since the duodenal musculature surrounded this diverticulum, its contraction would keep the diverticulum empty. The patient reported her condition regularly until she was in her twenties. During this time she had married and had had several children.

Even though this operation has been entirely satisfactory, were I to do it again I would divide a high loop of jejunum, bring the distal end up and anastomose it to the cyst and reconnect the proximal end to the side of the jejunum distal to the anastomosis to the cyst. This, I believe, was the sixth or seventh case reported and the first to be cured or relieved of symptoms.

DR DONNEIL B COBB, Goldsboro, N. C. There is little one can add to the informative presentation Doctor Brindley has just made. I would like to present one case which might be of interest since it deals with a child who was operated upon twice for lymphangioma of the mesentery, with an interval of six years between operations.

At the time of the first admission the child was $3\frac{1}{2}$ years old. During the previous year the parents had noticed that the child's abdomen was gradually increasing in size, and the child complained occasionally of an indefinite abdominal discomfort. Four days before admission the child developed nausea, vomiting and constipation, and this was associated with a constant, rather severe pain centered about the umbilicus. On admission the child presented a severe picture of intestinal obstruction and palpation of the abdomen revealed a large mass beneath the umbilicus about the size of a grapefruit.

At operation a very large cyst was found, arising between the leaves of the mesentery of the ileum. The upper part of this cyst was adjacent to the origin of the superior mesenteric artery, in which neighborhood there exists the fetal retroperitoneal lymph sac from which arises the lymphatic vessels which drain the small intestine. In attempting to remove the cyst, which was multilocular, it ruptured, spilling a large amount of milky fluid. The sac, however, was easily removed by stripping it away from the mesenteric vessels with gauze dissection, and the opening in the mesentery was easily closed. We did not experience the difficulty encountered by Doctor Brindley.

The pathologic picture showed the cyst wall to be composed of fibrous and vascular tissue of various density.

The child recovered and six years later was readmitted to the hospital. During the interim she had been perfectly well. Ten days before the second admission she began to have pain in the left upper abdomen and, at that time, the parents first noticed a mass in this region about the size of an orange. At operation this was found to be a similar but much smaller lymphangioma, arising between the leaves of the mesentery of the upper ileum. It was readily removed in a like manner and the pathologic picture was similar to the original lymphangioma.

One of the most important points to bear in mind in dealing with any lymphangioma is the unusual danger of infection. This was first pointed out by Doctor Singleton when he addressed this Association in 1936. At that time he emphasized the point that channels draining lymphangiomata do not always pass through filtering lymph nodes and at times the lymphangiomata have a direct fistula connection with adjacent veins. Thus, if infection does occur, it has ready access to the general circulation. At that time Doctor Singleton quoted Dowd, who had collected 90 cases, most of whom were operated upon with a mortality of 42 per cent, and in nearly all the fatal cases death was due to infection.

DR G. V. BRINDLEY, Temple, Texas (closing). I appreciate the discussions very much and, in particular, the interesting case reported by Doctor Cobb.

JEJUNAL DIVERTICULOSIS COMPLICATED BY THE DEVELOPMENT OF JEJUNO-COLIC AND JEJUNO-JEJUNAL FISTULAS —

Report of a Case*

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SURGICAL COMPLICATIONS of jejunal diverticulosis are exceedingly rare. Of the 350 odd cases of jejunal diverticulosis recorded in the literature, less than 60 developed complications requiring surgery. A case of diverticulosis of the jejunum with jejuno-colic and jejuno-jejunal fistulas is presented in this paper. We have been unable to find any similar case in the literature.

In 1945, Walker²⁵ collected 32 cases of acquired diverticulosis of the small intestine with complications. In this review he excluded congenital diverticula of the Meckels' type but included other single diverticula. Among the 122 cases of non-Meckelian diverticula of the jejunum and ileum presented by Benson, Dixon and Waugh² of the Mayo Clinic, there were 13 cases with complications. More recently several other case reports have appeared describing complications of jejunal diverticulosis^{13, 17, 19, 27, 28}

Approximately one-half of the recorded complications have resulted from diverticulitis, the inflammatory process leading to peritonitis with or without perforation, abscess formation, or acute intestinal obstruction from edema, kinking, or adhesions. Enteroliths, parasites and other foreign bodies, in many instances causing obstruction, have been found in jejunal diverticula^{24, 26, 18}. Hemorrhage has been reported as a major complication in at least four instances^{3, 11, 23, 15}. Acute and chronic intestinal obstruction resulting from a volvulus in association with jejunal diverticula, have been recorded three times^{9, 22, 13}. Three cases of traumatic rupture are described in the literature^{4, 1, 21}.

Benson, Dixon and Waugh² have recently added several new complications. They presented cases in which there was evidence of chronic intestinal obstruction with dilatation and hypertrophy of the bowel, apparently on a functional rather than a mechanical basis. They also reported a benign fibroma arising in a diverticulum of the ileum and an adenocarcinoma in a jejunal diverticulum.

CASE REPORT

A colored female, age 41, was admitted to Saint Philip Hospital on December 12, 1946, complaining of intermittent diarrhea, associated with tenesmus and fecal incontinence. She stated that undigested food was frequently passed in the stools shortly after eating. These symptoms had been present for 18 months. Four years the patient had suffered anorexia and occasional vomiting. No blood or mucus had ever been noted in the stools. During the year prior to admission she had lost a considerable amount of weight. Liver extract had been prescribed for anemia. Menopause had occurred at the age of 35.

* Read before the Southern Surgical Association at Hollywood Beach, Florida, December 10, 1947.

JEJUNAL DIVERTICULOSIS

On admission the pulse was 86, respirations 18, temperature 99 degrees, blood pressure 100/56. Physical examination revealed a poorly nourished, emaciated female. The mucous membranes were pale. Abdominal examination showed slight distention and tympany, but no tenderness. No mass or organ was palpated. Hyperactive peristalsis was heard.

Significant laboratory findings included an anemia of 3,900,000 red cells with 66 percent hemoglobin, a calcium of 8.6 and total serum protein of 4.9. Stools were negative for blood, ova, and parasites.

A barium enema by Dr. Edith Miller of Petersburg, Virginia, performed prior to admission had demonstrated a rather free connection between the transverse colon and the jejunum. With exception of irritability and spasticity of the transverse colon, no



FIG 1 Showing three jejunocolic fistulas to the transverse colon

other abnormalities were noted. A gastro-intestinal series failed to visualize a communication between the small intestine and colon, but the barium entered the colon very rapidly, evidently through the fistulas.

After adequate preoperative preparation, an exploratory laparotomy was performed. A large portion of the small bowel was found bound together by old, thick adhesions, and to this region the transverse colon was adherent. Dissection revealed a large number of diverticula present in the loops of jejunum. These were located on the anti-mesenteric and lateral portions of the bowel as well as along the mesenteric border. Although most were small and covered with a thick bowel wall, some measured $\frac{3}{4}$ inch in diameter and possessed only a very thin, transparent covering. One of the thinnest was ruptured during dissection and was excised. Three of the large diverticula were excised and their bases inverted. Further dissection uncovered three jejunocolic fistulas to the transverse colon (Fig 1). These originated from a short segment of jejunum and the attachments to the colon were approximately 3 inches apart. Each fistula measured 1 inch in length. The fistulas were removed by clamping and dividing their bases flush with the jejunum and

colon Eight jejunocolic fistulas were also demonstrated, but these were not disturbed (Fig 2)

Pathologic examination showed the thin wall of the large diverticula to contain only mucosa and a thin layer of muscularis while the fistulas were made up of normal jejunal wall with all its layers

Postoperatively the patient did well with the exception of one episode of atelectasis in the right lower lung Diarrhea was checked immediately following operation

A follow-up five months after operation disclosed that the patient was asymptomatic and had gained thirty pounds in weight A barium enema made at this time revealed an additional connection between the splenic flexure of the colon and the small bowel It was not clear whether this fistula had been overlooked at the time of operation or whether it



FIG 2—The jejunocolic fistulas One small and one large diverticulum indicated by arrows

had formed during the postoperative period A gastro-intestinal series failed to demonstrate the connections The absence of any functional shunt in the direction of jejunum to colon probably accounted for the freedom from symptoms

Discussion—Jejunocolic fistulas arising from peptic ulceration and from neoplastic invasion are not uncommon In addition, there have been instances in which this complication has resulted from sigmoid diverticulitis

Since no diverticula were noted along the colon, it is assumed that the formation of fistulous tracts between jejunum and transverse colon and between loops of jejunum developed from jejunal diverticulitis with secondary erosion into neighboring bowel This is further indicated by the gross and microscopic examinations which showed the fistulous tracts to be of jejunal origin Diarrhea and malnutrition followed the establishment of jejunocolic fistulas

A predisposing factor in this unusual complication may have been the location of many thin diverticula on the anti-mesenteric and lateral sides of

the bowel. In 1906, Gordinier and Sampson¹⁰, comparing jejunal and sigmoid diverticula, stated (with reference to the former) "Their usual situation between the folds of the mesentery renders them less likely to undergo pathologic changes than those hanging free." Here he refers to the location of sigmoid diverticula on the anti-mesenteric and lateral borders and the occurrence of complications in these. However, additional factors rendering jejunal diverticula somewhat immune from inflammatory changes are the liquid nature of the fecal stream in this region and the wide openings of the diverticula into the bowel tending to eliminate stasis.

The usual location of multiple diverticula of the jejunum between the leaves or just to one side of the mesentery has been noted by almost all authors. Single diverticula have not infrequently been found on the anti-mesenteric border, this location perhaps indicating a congenital origin. Edwards⁶ stated that multiple jejunal diverticula arose just to one or the other side of the mesenteric attachment, corresponding to the entry of the blood vessels supplying the bowel wall. Klebs¹⁴ first contended that the blood vessels created a weak spot in the intestinal musculature thus permitting herniation of the mucosa as a small diverticulum. This theory of the production of diverticula in association with the entry of blood vessels through the muscle layers, just to one side of the mid-line on the mesenteric border, has gained acceptance by many authors. However, it is now generally agreed that the small jejunal diverticula do not represent true herniations of the mucosa but rather are covered by all layers of the intestinal wall. Many other theories have been proposed to account for the production of jejunal diverticula. Fraser⁸ demonstrated an absence or weakness of the longitudinal muscle layer in the mesenteric region. Rankin and Martin¹⁶ concluded that an inherent weakness in the bowel in addition to increased intra-intestinal pressure were the major factors. However, the role of increased intra-intestinal and intra-abdominal pressures is difficult to evaluate and the importance of sclerosis of mesenteric vessels, increased venous congestion, fatty deposits and other proposed factors cannot be substantiated. In order to produce an effective increase in intra-intestinal pressure, Edwards⁶ contended that an irregular, segmental contraction of the bowel wall was necessary with relaxation of the intervening segment.

Benson, Dixon, and Waugh² stated that jejunal diverticula might occur in any position around the circumference of the bowel, the majority being situated along the mesentery or within its leaves. These authors did not state whether this applied as well to multiple as to single diverticula. In our case, many diverticula arose directly on the lateral and anti-mesenteric sides of the bowel. Association of these diverticula with entry of blood vessels through the muscle layers of the bowel wall would still be possible since branches of the arterial supply penetrate at increasingly oblique angles around the circumference at various intervals from the mesenteric edge.

Formerly, a careful distinction was made between "true" and "false" diverticula, the former term indicating those in which all layers of intestinal wall were present, the latter in which only mucosa and serosa were found. This distinction has also been the basis of division into congenital and acquired diverticula. Edwards⁶ in his extensive discussion of the subject stated that the mucous membrane herniated through a weak spot in the muscle wall carrying a few muscle fibers with it. A similar view was expressed by Fraser⁸. However, Butler⁴ claimed that in the early stage the diverticulum consisted of all coats, the mucous membrane later herniating through. Rankin and Martin,¹⁶ and Benson, Dixon and Waugh² likewise pointed out that diverticula, when small were covered by all layers of the bowel wall. Schmidt and Guttman²⁰ found all the stages of transition between the two forms, and expressed the view that much confusion would be avoided if diverticula were referred to without reference to the presence or absence of muscle layers. It has even been stated that congenital diverticula may become sufficiently enlarged and stretched as to show the characteristics of the so-called "false" type.

Although the smaller, thick wall diverticula in our case were not removed, grossly they gave the appearance of possessing essentially normal bowel wall in contrast to the large, thin, transparent diverticula which showed no muscularis externa microscopically.

Although many jejunal diverticula were present only a few were demonstrated by gastro-intestinal roentgen-ray study. Difficulty in radiologic diagnosis has been frequently mentioned and attributed to the wide openings of the diverticula. In 1920, Case⁵ presented the first five cases diagnosed by roentgenogram. In 1937, Johns¹² found only 26 cases diagnosed by roentgen-ray examination and of these, only 17 had been confirmed by operation. That multiple diverticulosis of the jejunum has been recognized with increasing frequency on roentgen-ray examination is illustrated by the fact that 16 of the 122 cases presented by Benson, Dixon, and Waugh² were diagnosed by barium studies. Ritro and Votta¹⁷ found 25 cases of multiple diverticulosis of the small bowel out of 4,786 roentgen-ray studies of the gastro-intestinal tract over a period of 2½ years, an incidence of one-half per cent.

The symptoms presented by our patient resulted primarily from the presence of jejuno-colic fistulas. However, anorexia and intermittent vomiting may well be attributed to the presence of multiple diverticula. In the absence of frank complications, multiple diverticulosis of the jejunum is a relatively silent disease. A few patients however, will complain of abdominal discomfort, flatulence, anorexia, and epigastric pain tending to radiate to the left of the umbilicus. Epigastric pain and fullness are said to be relieved by lying down. Ritro and Votta¹⁷ stated that 22 of their 25 patients diagnosed by roentgen-ray gave a history of abdominal complaints, anorexia being present in 50 per cent and nausea and vomiting in almost 50 per cent. Epigastric distress was the most common complaint. The absence of symptoms

associated with jejunal diverticula is probably related to minimal stasis in the sacs and to the presence of only a thin muscle layer covering the diverticulum

SUMMARY AND CONCLUSIONS

- 1 A case illustrating a rare complication of jejunal diverticulosis is presented
- 2 The occurrence of multiple jejuno-colic and jejuno-jejunal fistulas in this case may be attributed to the presence of multiple diverticula along the lateral and antimesenteric borders as well as the usual mesenteric location

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DISCUSSION —DR LUCIAN H LANDRY, New Orleans There is nothing that I can add to Doctor Williams' splendid presentation I only wish to add a case to this report that came under my observation in October of this year, of a single giant diverticula of the jejunum, without fistulae, however, which presented numerous difficulties so far as diagnosis was concerned In fact, I think we tried to make almost every diagnosis fit the case from ruptured intervertebral disk to housemaid's knee!

The patient had frequent melanotic stools with griping pains in the umbilical region, so much so that it was thought he might have a liver abscess Mesenteric thrombosis was also considered, as well as possible reduplication of the jejunum Later he developed a large tympanic mass filling the epigastrium, which we took to be a dilated stomach and suggested inserting a Levine tube to allow the gas to escape The patient stated that it could not be stomach as the mass was still present after vomiting We then had a gastro-intestinal picture made, which you will see in the slides, showing some barium in

the stomach which is riding above this large balloon-like mass, fully the size of a large grapefruit, partly filled with barium. The second slide shows the large balloon fairly well emptied of barium but still leaving a large gas bubble. Even our very good radiologist refused to "stick his neck out" and make a positive diagnosis from this picture.

At operation we found a large solitary diverticula of the jejunum. A resection and anastomosis was done without any difficulty, but unfortunately the patient died of a heart complication.

DR LON GROVE, Atlanta, Ga. I have enjoyed Doctor Williams' interesting discussion. We have recently seen a 69-year-old woman with a small bowel obstruction due to multiple diverticuli of the ileum. This is the first time we have encountered small bowel obstruction caused by diverticuli. This patient was admitted with symptoms of small bowel obstruction with ileus and was treated with Miller-Abbott tube. Later, x-rays were made, and we were able to demonstrate several large diverticuli of the terminal ileum with no other cause for obstruction. Because of her age, if further evidence of obstruction is manifested, we will probably advise ileo-colostomy. The diagnosis was made only a few days before I left Atlanta and we were unable to have a slide prepared for this meeting.

DR JAMES D RIVES, New Orleans. I am in a position somewhat similar to that of Doctor Mayo—I want to discuss a condition that I have not yet seen. A short time ago I operated on a patient with an acute penetrating ulcer, with duodenal obstruction resulting from inflammatory reaction which made resection not feasible at that time. It was demonstrated on gastro-intestinal study that he had multiple diverticula of the jejunum. As might be expected, he developed a gastrojejunal ulcer. I resected the involved section of the jejunum and did a subtotal gastrectomy with an anterior Polya anastomosis. The base of the ulcer was the wall of the transverse colon. The segment of the jejunum used in the anastomosis contained no diverticulum so far as I could tell.

There was relief for about three months and then symptoms recurred. Directly opposite the anastomosis is a large diverticulum lying on the transverse colon. The patient has refused further operation, for which no one can blame him, yet it seems to me he will develop a gastrojejuno-colic fistula if something is not done about it, and since he has twenty-five or thirty diverticula distal to the anastomosis, it is difficult to decide what should be done.

DR JOSEPH E J KING, New York. About four years ago I operated upon a friend of mine for intestinal obstruction. Flat films indicated that the point of obstruction was somewhere near the midportion of the small intestine, with major distension in the lower half of the abdomen. When the hand was passed in various directions in the lower portion of the abdomen the site of the lesion was not determined. However, when it was passed high up toward the stomach, the point of obstruction was detected and, with slight maneuver the entire intestine became free and uncoiled itself like a bull whip. After extension of the incision somewhat higher, it was observed that the obstruction was due to mild fixation of a coil of small intestine to a large diverticulum of the jejunum about five inches below the ligament of Treitz. In fact there were two diverticula situated about two inches apart on the mesenteric side. The larger one was about $1\frac{1}{2}$ inches or $1\frac{3}{4}$ inches in diameter and the smaller about one inch in diameter, and each had multiple diverticula of the diverticulum. Under the circumstances no attempt was made to remove these diverticula.

The patient made an uneventful recovery and has remained well to date.

DR CARRINGTON WILLIAMS, Richmond, Va. (closing). I want to thank you for the discussion, and I want to call your attention to Howard Mahorner's recent paper on diverticula of the jejunum and duodenum. Some are difficult to demonstrate and he has some very ingenious means to disclose their presence.

DIPLOIC EPIDERMOID AND EXTRA-DURAL PNEUMATOCELE CRANIAL DEFECTS AND DEFORMITY*

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THERE ARE MANY VARIETIES of cranial defects, erosions and deformities. The vast majority of these cases result from tumor, infection or trauma, while a lesser number is congenital. The various types of erosions and deformities of the skull associated with meningiomas are usually recognized quite easily. Defects produced by metastatic malignant tumors have a characteristic appearance, show an indefinite "fuzzy" margin and are readily diagnosed on radiographic films. This applies to cranial defects following trauma, osteomyelitis and other diseases.

None of the above mentioned types falls within the scope of this paper. I wish to call your attention to two types of cranial defects, erosions, or deformities caused by—1 diploic epidermoids and—2 extradural pneumatocele of spontaneous origin. Each has a most distinctive and characteristic appearance. Each can and should be diagnosed pre-operatively, and the proper operative procedure can be carried out definitely and precisely, with a great saving of time for the surgeon, and with a corresponding advantage to the patient.

The pathologic and histologic features will not be reviewed, since they have been adequately considered in other papers, e.g. Bailey,¹ King,² Schwartz,³ etc.

DIPLOIC EPIDERMOIDS

Epidermoids arising from the diploë of the skull produce two distinct types of defects on roentgenographic films. The less common type destroys the outer table of the skull and thins out the inner table. The tumor mass is entirely extracranial. The inner table is not perforated, but the mass has a remnant of the outer table of the skull extending for an indefinite distance, eggshell in thickness, over the proximal periphery of the doughy tumor. This lesion is well described by Bucy.⁴

The majority of diploic epidermoids destroy the inner, rather than the outer table of the skull. The lesion evidently arises from a diploic congenital epidermal rest or anlage. It increases in size, and over a prolonged period of time, destroys the inner table of the skull. It grows inward and depresses the dura, and may perforate the dura before the outer table of the skull gives way, except at certain areas overlying the mass. There may be, and usually are, a few areas of destruction of the outer table with smaller openings or lacunae, and thinned out portions of the outer table, between the several openings. There may be "islands" of the outer table of the skull between the openings, of eggshell thickness and consistency, but this condition is less

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Wednesday, December 10, 1947.

seldom encountered. At any rate, the pressure exerted by the very slowly enlarging mass is *irresistible* and the bone gives way. The inner table is destroyed except for a margin near the periphery 1 cm to 1.5 cm wide, which is depressed downward and inward by the slowly advancing tumor. It will measure about 2 to 3 mm in thickness at its continuation with the normal inner table, and gradually becomes of cellophane thinness at its free margin, and bends and fractures easily.

Overlying the lesion a mass may be palpable, varying in size, and doughy in texture, if a considerable portion of the outer table is destroyed. Otherwise, areas of complete destruction can be detected by the fingers. In no case has impulse on coughing or pulsation been observed. The scalp over the area involved is usually elevated about 1 cm or more above the remainder of the scalp. The amount of elevation depends largely, but not entirely, on the amount of destruction of the outer table.

Roentgenographic films, stereo-lateral and antero-posterior, reveal a skull defect so characteristic that it should never be confused with any other lesion. This characteristic picture of the lesion is well portrayed by Dr. Cushing's¹ illustration in his paper in *Surgery, Gynecology and Obstetrics*, May 1922. Although he did not make a preoperative diagnosis, he said that one *should* make a preoperative diagnosis based on the typical roentgen-ray findings produced by the lesion.

The author² read a paper on this subject in 1938 before this Association, and reported eight cases of epidermoids. The first one, operated upon in 1923, was almost a duplicate of Dr. Cushing's case except that it was on the opposite side of the skull and there was a slight difference in size. The area of skull involved was the same, i.e. the fronto-temporo-parietal region. The diagnosis of the lesion was made before the operation, based on the detailed description of the cranial defect given by Dr. Cushing, and so far as can be determined, this was the first time a positive preoperative diagnosis of this tumor was made.

I shall repeat from this paper the description of a typical diploic epidermoid involving the cranial vault, with greater destruction of the inner than the outer table of the skull.

"A typical cranial defect produced by the diploic type, in which the inner table is more involved than the outer, when viewed so that the greatest diameter of the defect is shown, has a scalloped, dense, clear-cut margin, showing that this bony margin is more compact than the remainder of the skull. One or more bony hiatuses may be observed in the skull. These represent areas where the outer table of the skull has been completely destroyed. These openings, if they exist, are more apparent on stereoscopic films. The margin of these lesser defects may also be dense and sharply defined. Small pieces of detached islands of bone may be seen. The outstanding and differentiating feature of the cranial defect, however, is the sharply defined, dense, white, scalloped margin which is found in no other condition. Any other eroding lesion, regardless of its nature, produces

a defect in which the margin is less sharply defined, more hazy, and may be fuzzy and soft

If the roentgenogram is taken so that one views the defect "on edge" as though looking at a saucer edgewise, a dense line about 2 mm or more wide will be seen extending from the upper to the lower limits of the defect. This is due to superimposition of the dense margins of the defect which brings the compact bony margins in alignment. The outer table may be so thin that it may not be visible at all in an under- or over-exposed film. The characteristics of the defect are positive and unmistakable."

The lesions reported vary in size from about 1.5 cm in diameter to 7.5 cm or more. The distinctive features of a cranial defect caused by this lesion are more apparent on roentgen-ray films of the larger than of the small tumors. The scalloped border is more marked and the density of the margin of the defect is more apparent. It is believed that the density of bone forming the margin is due to the slow, steady, prolonged pressure exerted by the tumor on the bone about its periphery, which produces solidification by compression. The bony structure is compressed by the irresistible force of the slow growth of the tumor and not invaded and destroyed by tumor cells as in the case of meningioma or the malignant lesions. Compression, producing increased bone density at the margins of the defect, is far in advance of the destruction of bone. The major force of the tumor in its expansion affects to the greatest degree, that part of the skull which offers the least resistance, that is, the inner or outer table. The greatest resistance offered to the tumor is at its periphery where the surrounding bone is a strong bulwark or buttress. The inner table is completely destroyed for the most part and the tumor mass may occupy a relatively enormous amount of intracranial space compared with the smaller diameter of the cranial defect. Giving away and destruction of the inner table minimizes but does not stop the pressure on the margin of the periphery.

The hollowed, scalloped margin is lined with an epithelial lining—the only viable portion of the tumor—and the epithelial cells do not invade the bone. Practically all of the lesion seen at operation consists of the exfoliated epithelial cells cast off from the inner, older layer of the epidermal lining. Were it possible for these dead exfoliated cells to be discharged through a small fistulous tract through the scalp as fast as they are exfoliated, there would be no expansion of the growth, no compression and destruction of bone, no apparent cranial defect,—and no opportunity to discuss this subject.

In 1936, Mahoney⁶ reported a case of unusual design and pattern, but presenting a definite sharp line about the margin of the defect. In 1936 Love and Kernohan⁷ made the preoperative diagnosis in "Case 9." The diagnosis was based on the presence of a doughy mass in the temporo-parietal region and the roentgenographic findings. Munro and Wegner in 1937⁸ reported a case of epidermoid of diploic origin. They stated "X-rays showed bony defect pictured in Fig. 1." A preoperative diagnosis was not made (at least not stated) but the illustration presents the typical cranial defect produced by

a diploic extradural dermoid. In 1939 Alpers stated⁹ "Skull cholesteatomas (epidermoids) may be diagnosed before operation since they have a characteristic roentgenographic picture." In 1940 Love and Bailey¹⁰ made the pre-operative diagnosis in a case in which the tumor involved the left half of the occipital bone. This large tumor weighing 200 Gm displaced the occipital

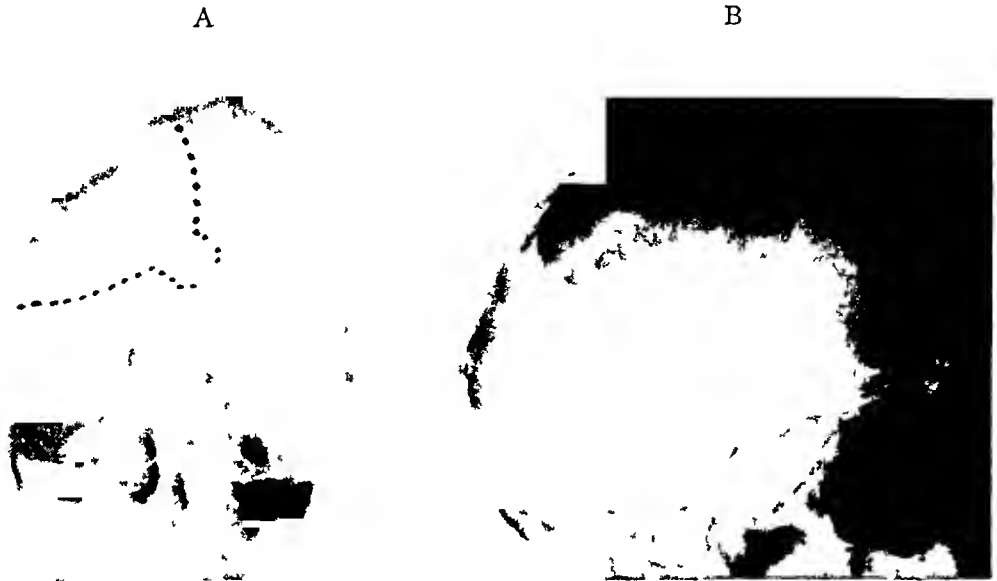


FIG 1 (a and b) Case 1, W M Roentgenograms of skull (a) Postero-anterior view showing defect and approximate size and shape of tumor (b) Lateral view showing definite white, dense, scalloped margins and bone destruction

lobe to a marked degree upward and forward and the cerebellar lobe downward and forward. The tumor was removed completely.

In 1943, in a report of a large series of cases, Rand and Reeves¹¹ stated the following:

"That the diploic or cranial epidermoids may often be confusing unless one has their identifying characteristics in mind is evident from the eleven cases just presented. So typical is the roentgenographic appearance of the growth that usually the preoperative diagnosis can be established from the films. In spite of this fact, these tumors are undiagnosed. Four of the tumors in our series of cases were operated upon as sebaceous cysts. In Case 4, four operations were necessary before complete removal was effected. The diagnosis was established only after roentgenograms were reviewed. After an incomplete removal in Case 5, the patient had repeated aspirations for a period of four years. She was then seen by someone familiar with the diagnosis. A review of the roentgenograms taken four years previously revealed the characteristic picture of a cranial epidermoid."

Because the diploic or cranial epidermoids are so easily diagnosed and can be treated so successfully surgically, it is important that they be recognized before they reach a size which might make complete removal impossible. The importance of this fact is seen in Case 9."

In 1944 Thornhill and Anderson¹² reported a case of diploic epidermoid of the frontal region which produced unilateral exophthalmos. Although a positive diagnosis was not made before operation, an epidermoid was sus-

pected. The nature of the lesion was recognized at operation, the entire mass was removed, and the postoperative course was uneventful.

The rate of increase in size of the tumor is not known. It may be almost as old as the patient. Decidedly it is a lesion of slow growth. One may obtain some idea as to its slow development and increase in size by review of Case 9 reported by Rand and Reeves in March 1943. The presence of the tumor was determined definitely when the patient was nine years old at which time it was thought to be a wen or sebaceous cyst of the scalp. For the tumor to be detected, it probably had pre-existed for a period of months or perhaps years. Operations were performed at the ages of 34, 36, 64 and two operations were done subsequent to the age of 64.

Since the original report the author has operated upon four cases, two of which had refilled with epidermal debris, in cases where all the epidermal lining could not possibly be removed,—one after 11 years,—and two new cases. One of these shows several rather unusual features. It is the largest diploic epidermoid operated upon by the author and the largest reported in the literature, so far as can be determined. Horrax, Yoishis and Lavine¹³ reported an enormous *intradural* epidermoid, encapsulated with a calcified capsule. This, however, is not the type of lesion under consideration.

CASE REPORTS

Case 1—Bellevue Hospital, History No. 5-166 and 34161-42. *Epidermoid, diploic, extradural, fronto-parieto-occipital region, large. Dural invasion and perforation. Preoperative diagnosis made. Operation with complete removal. Resection of dura with fascia lata graft. Recovery.*

W. M. White, male, age 54, married, laborer. Admitted June 22, 1942 as a first admission complaining of weakness of the left leg for two years.

Past history—Fracture of both bones of the right leg in 1917. Kidney stone removed ten years ago. Asymptomatic since. Pneumonia in 1921. Appetite good and drank moderately until a few years ago. Appendectomy several years ago.

Present illness (history obtained by Resident)—Onset began ten years ago (1932) when he fell from a ladder and struck the right side of his head. Unconscious for unknown length of time, remembers hearing people talk, but could not answer. Sent to Columbus Hospital, stayed a few hours and went home. About two weeks later roentgenographic films were made and reported negative. Remained away from work 5 to 6 weeks. The first time he tried to climb a ladder he was dizzy, stepped down, and then climbed the ladder again. No trouble since until two years ago (1940) when he felt awkward and had difficulty with his left leg going up and down stairs. This has continued to the present time. A few weeks ago he struck his left shin and it became infected. He was admitted to the hospital. Following discharge he was referred to the Neurologic Clinic of Bellevue Hospital.

He noted on occasions tingling and numbness in tips of left fingers over a period of months. In the spring of 1941 he was standing on the dock watching a ship pull out. He had a sensation of being drawn in the direction of the vessel and fell into the water. He was taken to Harlem Hospital. Apparently nothing was noted, and he was discharged. Since then he has had a throbbing sensation in the right frontal area. No diplopia, no spots before the eyes.

Neurologic examination—The patient was alert, cooperative and well oriented as to time and place. "Osteoma" (?) of right parietal area. Pupils reacted to light and

convergence Left pupil larger than right Fundi—right disk clear, left blurred, with 1 plus elevation Arterio-sclerotic changes of vessels of both sides E O M intact Left peripheral facial weakness, apparently old Other cranial nerves intact Deep tendon reflexes of upper extremities equal, biceps somewhat increased Knee jerk slightly increased on left Abdominals absent on left, present and active on right Cremasteric present and equal Babinski equivocal on left, absent on right Some weakness in flexion of left thigh on trunk Slight weakness of left arm, none of extensors and flexors of feet

Sensory intact to pinprick, cotton, temperature and vibration Position sense unimpaired When walking, slight eversion with tendency to drag left foot

Past pointing test—Left arm shows slight gross tremor Heel to knee test in left leg negative

Laboratory data—Urine clear, 1024, negative Blood WBC 6,200 polys, 41, lymphs 59, RBC 3, 900,000 hemoglobin 14.2 gm Wasserman negative NPN 29 Sugar 98

Lumbar puncture—Initial pressure 290, crystal clear Wasserman negative Cells 0 Total protein 34.3

Röntgenologic examination of skull (Fig 1a and b) (J E J K) *Lateral view*—“There is a large cranial defect of the right fronto-parieto-temporo-occipital region which presents all the typical characteristics of an epidermoid, but the largest ever seen by the observer It measures on the film 10.5 cm in the horizontal, and 9 cm in the vertical directions Upwards it extends so far that only the thickness of the skull appears above the limits of the defect, forwards 7.5 cm from the upper limit of the frontal sinus, downwards to within 1.5 cm of the upper border of the petrous portion of the temporal bone, backwards to within 6.5 cm of the external occipital protuberance The margins are definite and clear-cut, throughout, dense, white, about 1 mm thick, scalloped and typical of an epidermoid Several hiatuses or lacunae are present, some quite large, and in some areas the bony structure of the skull is very thin or probably absent (Schwartz reported a similar case) The remnants of bone overlying the defect present a bizarre picture,—like seas, bays, islands, lakes and peninsulas

On the *antero-posterior* view, the defect is clearly revealed The skull is eroded, the greatest amount of erosion being near the center of the defect where the outline of the outer table of the skull is barely perceptible for a distance of 3 cm The overlying bone presents a cloud-like appearance There is a distinct white line, about 1.5 mm thick which runs from a point near the vertex,—1.8 cm from the mid line, downward, slightly depressed and outward for a distance of 9.5 cm This white line results from the superimposition of the anterior and posterior dense margins of the defect This line is 4.5 cm from its central portion to the outer table of the skull The tumor itself, which cannot be seen, will be found to be enormous, and will extend much farther inward than the distance of the white line from the outer table of the skull

Diagnosis Epidermoid, diploic, extradural Complete removal of the tumor, including its bony margin, advised

Operation—July 2, 1942 Local anesthesia, novocain solution 1% and ½% with suprarenin After the head was completely shaved the outline of the bulging mass could easily be determined It measured approximately 10.4 cm in diameter and was elevated in the central portion about 1.5 to 2 cm above the surrounding area A horseshoe-shaped scalp flap, hinged below in the temporal region, was elevated and turned down It consisted of scalp, galea, and temporal muscle and fascia, leaving the pericranium attached to the skull Eight burr holes were made in the normal skull just beyond the margin of the tumor and the burr holes were connected with a deVilbiss forceps and Gigli saw, and the block of bone was loosened Normal dura was seen through the groove made by the forceps The block of bone was tilted upward and the typical pearly-white tumor mass came into view It was very large and bulky and depressed the dura and

brain about 8 cm at its central portion from the inner table of the involved skull. The tumor was not adherent to the dura except at its apex. It was gradually, easily elevated from its depressed dural envelope up to a certain point (Fig 2a). None of the tumor fractured off the main body. At its most advanced and deepest portion, the tumor had perforated the dura and a knob-like mass of the tumor about 2.5 cm in diameter and

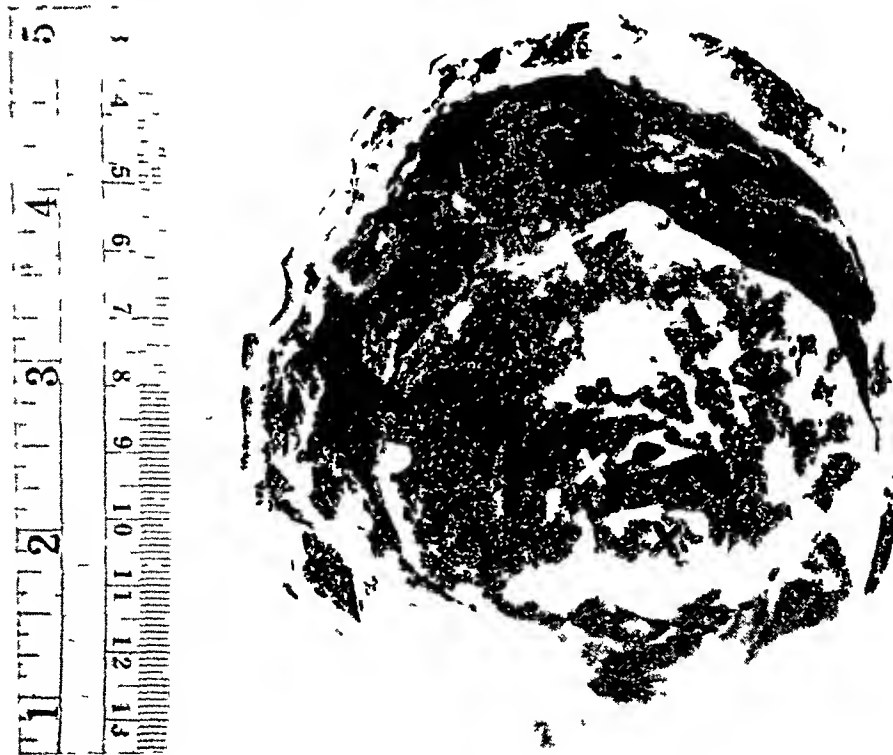
A



B

FIG 2—Case 1, W M (A) Elevation of tumor from dura (B) Shows protruding knob-like mass perforating dura. Dural edges seized with clamps

A



B

FIG 3—Case 1, W M (A) Lateral view of specimen, showing white pearly mass in bone segment, elevation of bone over normal skull and dural cuff rolled up around knob-like mass (B) Surface view of specimen showing tumor packed in bony saucer with safe margin, resected portion of dura and knob-like projection at x

DIPLOIC EPIDERMOID

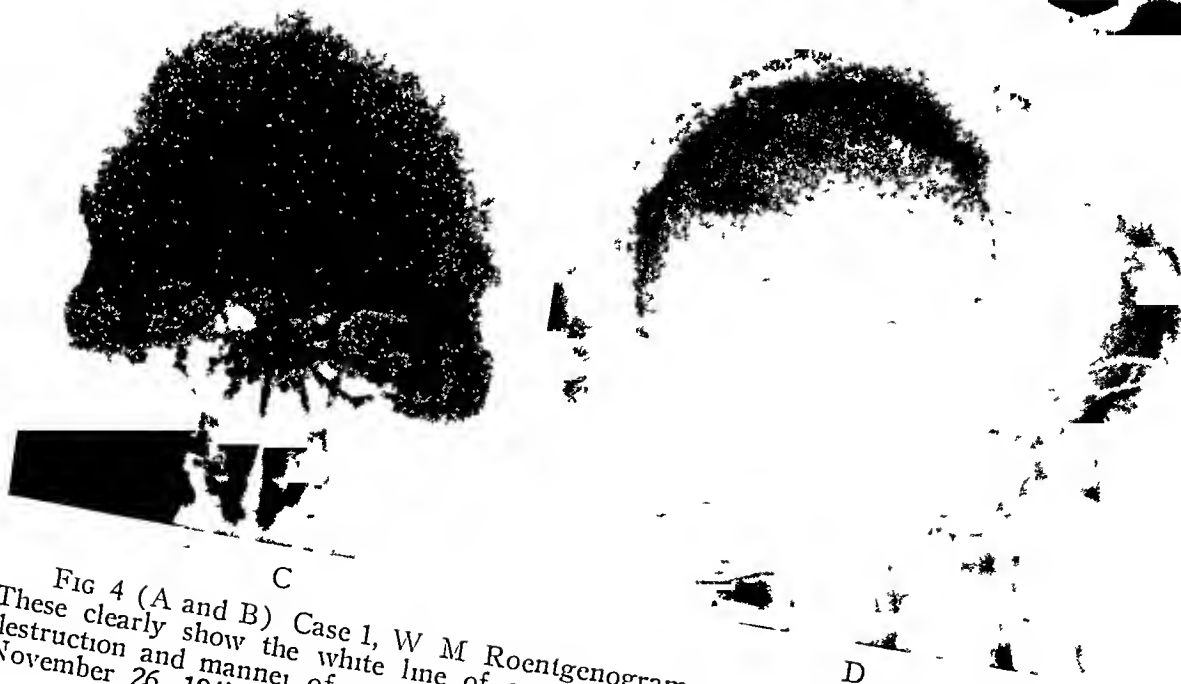
25 cm long protruded through the dural opening against the brain (Fig 2b) There was a distinct neck on the mass where it perforated the dura, about 15 cm in diameter, to which the dura was firmly adherent One was reminded of an old-fashioned football turtle-neck sweater drawn over the head

In order to effect complete removal *en bloc*, a circular portion of the attached dura measuring about 5 cm in diameter was removed and left attached to the tumor The knob-like protrusion had made a nest-like depression in the cortex and was very faintly adhered to it These light adhesions were easily separated, the entire tumor was delivered and removed intact (A description of the tumor and its bony cup will be given later)

There were no adhesions between dura and cortex The dura was considerably thinner in its central portion, which was excised The dural defect was closed with a

A

B



C

D

FIG 4 (A and B) Case 1, W M Roentgenograms of specimen Diploic epidermoid These clearly show the white line of condensed bone surrounding the defect, partial destruction and manner of erosion of skull C and D, Postoperative roentgenograms, November 26, 1947

transplant of fascia lata, the scalp flap was returned to position and the incision closed in two layers with interrupted silk sutures. The skull defect was not repaired because tantalum was not available and tibio-periosteal transplants were not considered advisable at the time on account of the size of the dural defect. The usual head dressing, covered with a plaster shell was applied. The patient left the table in good condition. Blood transfusion was not indicated.

Description of specimen—The specimen was unique in appearance. It reminded one of a shell or saucer over-filled with vanilla ice cream (Fig 3a). It consisted of a block of skull approximately circular in shape, 10 cm in diameter. The tumor mass remained intact, packed tightly within the confines of the bony shell. It was not removed from the bone. For this reason one cannot describe the color of the outer surface of the epidermal covering of the tumor lining the excavation. The exposed surface which was overlying the dura and in contact with it was pearly white, velvety and smooth. The knob-like projection, with its dural cuff turned up about it like a coat collar, is seen. The tumor was approximately $7\frac{1}{2}$ cm thick. The amount of elevation of the overlying outer table above the normal level of the skull could be seen. Fig 3b is a photograph of the inner surface of the lesion showing a safe margin of bone beyond the lesion, the pearly white surface and the knob-like intradural portion of the tumor with the excised circular dural segment. The outer table was elevated over the site of the tumor and resulted

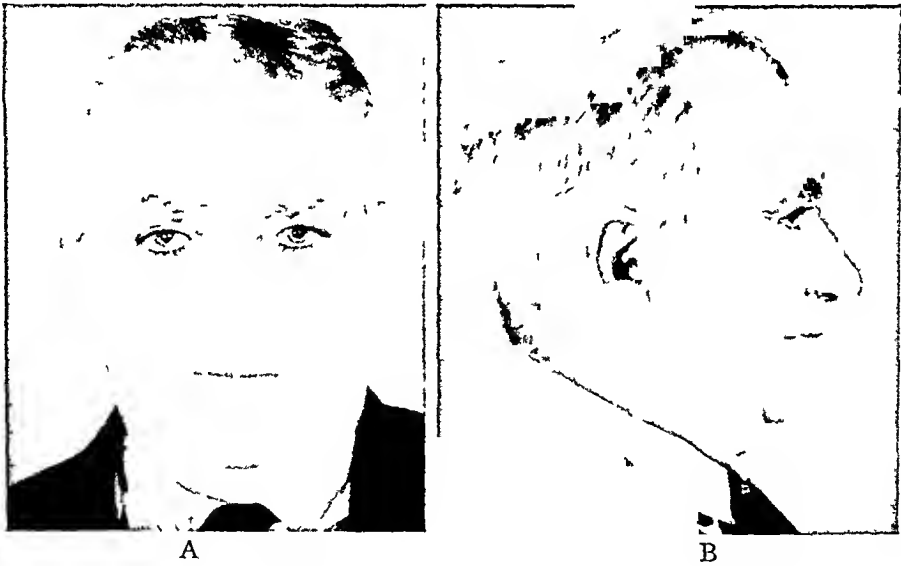


Fig 5 (A and B) Case 1, W M. Photographs of patient, November 26th, 1947

from prolonged sustained pressure from within. It is covered with pericranium. No definite holes can be seen, but there are a few small doughy areas. The total weight of the specimen was 310 Gm but the weight of the epidermal mass was not determined. Radiographic films of the specimen were made (Fig 4a and b). These accentuate the smooth clear-cut, sharply defined bony margin of the defect, and the smaller openings or lacunae, and the uneven destruction of the outer table.

Microscopic examination—"Shows in one section a well-defined thin cyst wall which is lined by a thin layer of stratified squamous epithelium. (No mention was made of kerathalyn granules, but these were present.) A small cyst is seen in section, filled with amorphous pink polyhedral bodies. Another section through the dura shows a similar layer of epithelium closely attached. In one area there is round-celled infiltration.

Diagnosis—Epidermoid (cholesteatoma)"

The postoperative course was uneventful. All weakness of the left leg disappeared.

DIPLOIC EPIDERMOID



Fig 6 (A, B, and C) Case 2, K MacK A Lateral, and B, postero-anterior roentgenograms of cranial defect C Postoperative lateral view

and, on getting out of bed on the twelfth postoperative day, he stated that he felt as strong as years ago Follow-up radiographic films made on July 23, 1942 showed the operative defect He was discharged on July 24, 1942 the 22nd postoperative day to Social Service, which provided him with a perforated celluloid protector to wear in his hat over the defect He was informed that a tantalum plate could be inserted after the War but he said he was satisfied He was later seen in the clinic and it was reported that he had returned to work

On a recent visit to the office, he stated that he was in splendid health and had no complaints The strength had completely returned on the left side He is working as a porter in a nearby apartment house and has never missed work on account of illness He wore no protector and did not want a cranioplasty He gained 40 pounds since discharge from the hospital His neurologic examination was negative There was

some flattening of the right side of his head, rather well concealed by his hair. The skull defect (Fig 4b) had filled in considerably about the periphery, but there was no reformation of bone in the central portion of the defect (Fig 5a and b).

Case 2—(Lawrence Hospital, History No 40711)—*Epidermoid, diploic, extradural, temporo-parietal. Preoperative diagnosis: Complete block removal. Resection of dura with fascia lata graft. Recovery.*

K MacK, white female, age 46, married, housewife, admitted Jan 17, 1940, referred by Dr O L Austin. Radiographic films of the skull had been made about two weeks previously and were shown to the author. A cranial defect was present in the right parietal region. It presented all the characteristics previously described in this paper—and the diagnosis of diploic extradural, epidermoid was readily made. Complete block removal of the tumor was advised.

History was essentially negative except for some pain in right shoulder last September. Roentgenographic films were made of neck, head and sinuses as a routine, and the lesion of the skull was discovered. She had been well otherwise, with no complaints. The examination was entirely negative except for slight increase in deep reflexes on the left side and a slightly elevated mass in the right temporo-parietal region.

Roentgenologic examination (J E J K)—"On the lateral view (Fig 6A) there is present a cranial defect of the right temporo-parietal region which measures 6 cm in the horizontal and 5 cm in the vertical diameter. The margins of the defect are mildly scalloped, very dense, firm, and sharply defined (Schwartz's Fig 1 presents an almost identical picture). There is gross destruction of the bone with some very thin areas in the outer table, and complete destruction of this table, especially in the anterior half of the defect where the doughy mass can be palpated.

The antero-posterior view (Fig 6B) shows a dense white vertical line about 2 mm in thickness and 5 cm long. The outer table is very indistinct due to thinning and destruction and can hardly be distinguished. The characteristics are so definitely those associated with diploic epidermoid that the diagnosis is unmistakable.

Diagnosis: Diploic epidermoid."

Operation—Since the patient did not want to be conscious during the operation, avertin and open ether anesthesia was used instead of local anesthesia. A horseshoe-shaped incision was made hinged on the temporal muscle below. The scalp flap including the pericranium was elevated and reflected. The pericranium was intimately adherent to the tumor where the outer table had been destroyed. Over these areas the pericranium was left attached to the skull so that the tumor would be left intact and could be removed en bloc. A burr hole was made above and below the margin of the defect in normal bone and burr holes connected with deVilbiss forceps. The bone segment was loosened. The dura was stripped from the shelf-like depressed margin of the inner table. The lining membrane of the tumor, as thin as cellophane, was carefully stripped away from the attenuated depressed dura towards the central portion of the depression. In this area the lining membrane was more firmly attached. To prevent leaving some of the membrane (which is the only viable portion of the tumor) and risking the possibility of recurrence, the central portion of the thin redundant dura was removed, still attached to the tumor mass. A dural defect about 3 cm in diameter remained. The dura was not adherent to the cortex. A fascia lata transplant was used to repair the dural defect and the repaired dura was floated up with warm saline solution to prevent adhesions between the site of the transplant and cortex. The scalp flap was sutured in two layers with interrupted silk sutures and a compressing head dressing was applied. The patient was returned to her room in good condition.

Inspection of the specimen—Segment of bone surrounding tumor measured about 6.5 cm in diameter with rim of skull $\frac{1}{2}$ to 1 cm wide. This was the only tumor of this type seen by the author, which destroyed both tables of the skull to such a marked degree. The two hiatuses in the outer table measured 2 cm by 4.5 cm and 1.5 cm, respec-

tively There was total destruction of the inner table beneath the mass, the defect measuring 5 cm in the horizontal, and 4 cm in the vertical directions The epidermoid mass was packed and stuffed into the cavity of the bony cup like a deviled crab The remnants of the inner table margin were depressed inward and fitted close to the tumor The extreme free edge was as thin as paper and had a feathered edge, like new-forming ice on a pond The tumor surface was pearly white, lamellated, smooth and glossy—typical of an epidermoid

Photographs and radiographs were made The mass was placed in decalcifying solution and the tumor with its surrounding bone was sectioned in halves on March 13, 1940 When laid open the two halves resembled somewhat an opened oyster Sections of the lining and bone to be made by the pathologists

Pathologic report "Epidermoid, skull"

Recovery was uneventful—Patient out of bed on eleventh day and discharged on the fourteenth postoperative day She has remained well with no complaints referable to her head Lateral roentgenogram was made about nine months after operation (Fig 6c) In 1944, a supra-vaginal hysterectomy was performed under spinal anesthesia for multiple fibromyomata Uneventful recovery

COMMENT

The largest diploic epidermoid ever seen by the author or reported was found in Case 1 Roentgenographic films in both cases revealed characteristic features of a cranial defect resulting from destruction by an epidermoid tumor Diagnosis was readily made in each case Block removal with resection of the dura and repair with fascia lata transplant was carried out to assure complete removal of the lesion The tumor perforated the dura in Case 1 Reinsertion of the block of bone, after curettage and boiling, was not done at the time, on account of the fascial transplant This procedure could readily have been done at a later date, but it was not desired by the patient in Case 1, and it was not necessary in Case 2

Preoperative diagnosis of this type of lesion can and should be made and complete removal should be carried out, except where the underlying dura contains an important structure, e.g. the lateral sinus In this situation curettage and application of Zenker's fluid must suffice

EXTRADURAL PNEUMATOCELE

Pneumatocele, ariocoele or pneumocephalus which follows compound fractures, gunshot wounds, etc. will not be discussed in this paper, and such conditions which have frequently been reported, are excluded

This report is concerned with two cases of spontaneous accumulation of air in the extradural space between the dura and the skull *without* perforation of the skull The resulting skull defect is so typical and characteristic that a preoperative diagnosis can and should be made Had I known what is to be reported here *before* operation was performed on my first case, the patient would have been spared much hospitalization and time lost from his work Had I not mislaid and failed to read the paper of Woodall and Baker,¹⁴ published in 1941, no doubt the same declaration could be made

The condition is rare and the radiographic films may be baffling and bizarre to the uninitiated, as they were to several of us in the first case

No one who observed these films had ever seen the like before. It was the consensus of opinion, including that of F M Lau (who made the films) that we were dealing with an hemangioma of the skull. No other diagnosis was made until after operation.

The roentgen-ray films are similar in their characteristics, the principal difference being in size and position. The proper preoperative diagnosis was not made in the first case, but was made in the second. There is no other lesion of the skull which resembles that produced by an extradural pneumatocele. A detailed description of the lesion will be attempted.

CASE REPORTS

Case 3—(Bellevue Hospital, History No W-65 and 10174-43)

Pneumatocele, extradural, parieto-temporo-occipital, right. Preoperative diagnosis not made.

Operation—*Re-accumulation of air with infection. Sequestration of part of bone block. Second operation. Recovery.*

J B White, male, aged 33. Married. Bus driver. Admitted as first admission on March 1, 1943.

History—Patient stated he was entirely well except for a running ear on the right side in childhood, until 1931 when he sustained a head injury. No roentgenograms were made. Said to have been bed-ridden for several weeks, but had no immediate sequelae. About 1934 he began to have occasional headaches which came on suddenly in the right frontal region. These headaches were sharp, stabbing, intermittent for a few days and then did not recur for months. In 1939 he had bouts of headaches for which he sought medical aid without obtaining relief. After several months they ceased, and became intermittent at irregular intervals.

On January 5, 1943 while pulling down the shade behind his seat in the Fifth Avenue bus, which he was driving, he lost his balance and struck the right side of his head against the seat, and he "saw stars." He was stunned momentarily, but was able to drive his bus for another hour when his day's work was finished. That night he had bloody discharge from his right ear, but no other sign or symptom. He worked all through the next day, during which he had intermittent bleeding from the right ear. That evening he was referred by the bus company's physician to Dr J Lore, who treated his ear and suggested that radiographic films of the skull and sinuses be made. Roentgenograms made by Dr F M Lau revealed a most unusual bizarre picture. The author was requested to see the films and the patient. On January 19, 1943 the patient was advised to be admitted to the Neurologic and Neuro-Surgical Service of Bellevue Hospital.

Physical examination—Patient is a well developed, well nourished and apparently healthy white male of age 33. His general appearance presents no abnormalities. Examination of the canal of the right ear and ear drum reveals a previously ruptured drum with dilatation of the capillary vessels and small veins around the drum. The left drum and canal are normal.

Neurologic—Patient well oriented as to time, place and person. Sense of smell grossly intact. Absence of physiologic cupping with blurring of the disk margins. Nerve heads appear normal. There is tortuosity and a mild amount of venous congestion. The disk margins of the left eye are hazier than those in the right. No papilledema can be definitely determined. EOM normal. Visual acuity normal. A C > B C on the right. A C = B C on the left. Weber lateralized to right. Other cranial nerves intact. Gait normal. Romberg negative, no signs of weakness or loss of muscle power. Ankle and knee jerks equal but somewhat exaggerated. Diminished abdominal reflexes. Neurologic examination otherwise negative.

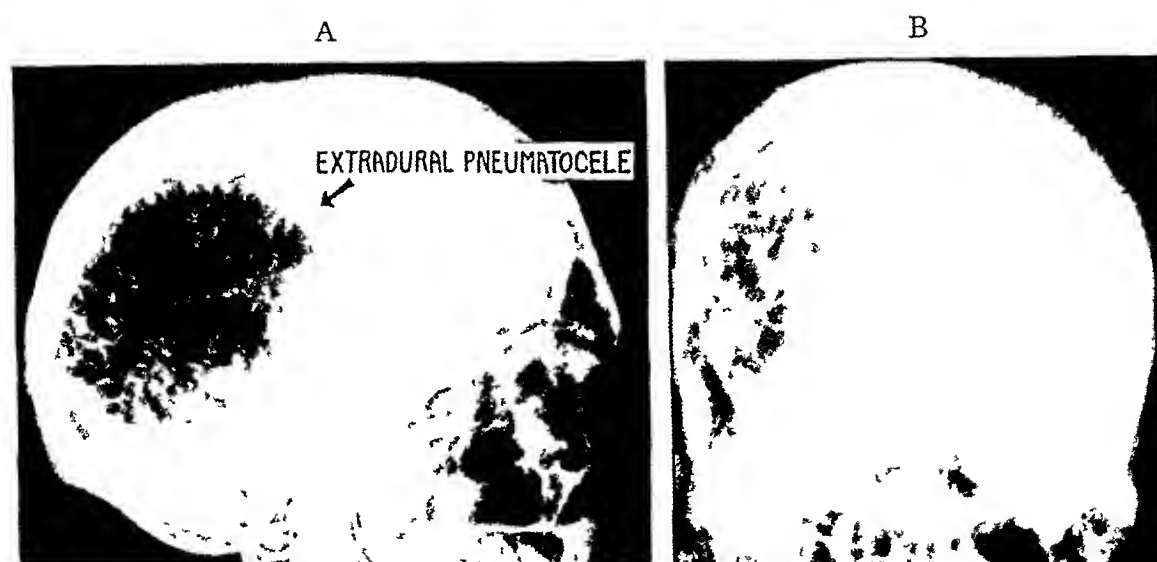


FIG 7—(a and b) Case 3, J B Roentgenograms of skull showing cranial defect produced by extradural pneumatocele

Laboratory findings—Urinalysis negative RBC 4,400,000 Hgb 13 Gm, WBC 7800, polys 68, lymphs 3, N P N 31, sugar 78 Blood type zero Wasserman negative Phosphatase 58, phosphorus 434, cholesterol 175, calcium 88, Spinal tap protein 35, sugar 60, Na Cl -750, Wasserman negative

Radiographic examination (Report by Dr Friedman)—“There is a large neoplasm 12 cm in diameter originating in the right parietal temporal and occipital lobes showing enormous cyst-like arrangements with calcium deposits Findings indicate calcifying *glioma*”

Roentgenographic findings (J E J K)—“*Lateral view* (Fig 7a) The cranial defect is ovoid in shape and measures 14.5 in the horizontal and 12 cm in the vertical diameter The involved area is much darker than the surrounding bone of the skull for the most part, i.e. there is a decreased density of the involved bone The margins are clear-cut and well-defined The print of the film gives the distinct impression of looking at the surface of a clean coral rock The area is trabeculated throughout, denser portions appearing lighter and thinner areas darker Some areas are almost black The margins are somewhat scalloped, and the scallops are smaller than those seen in films of epidermoids They are also more numerous The margins of the scallops are more distinct at some points and less distinct at others No point about the margin presents the fuzziness seen in cases of malignancy One should suspect, but it is not known to us at the time, that air is beneath the skull The shadow cast by the base of the petrous pyramid is very dense with a small external opening of the auditory canal The posterior portion of the mastoid shows no cells or else they are lost in the involved area There is distinct destruction of the posterior portion of the base of the petrus The part which remains presents a concave surface The eroded area “saddle-bags” the petrous ridge and dips into both middle and posterior fossae In the middle fossa the destructive process involving the squama reaches down to the level of the floor of the sella In the posterior fossa it extends as far as the base of the skull

Antero-posterior view (Fig 7b) —The film is similar to that of the case of Woodhall and Baker The “dark area” extends from high on the cranial vault from a point about 5.2 cm from the midline, downward into the middle fossa below the petrous pyramid, a distance of 15 cm There is some destruction of the base of the petrus and this section is not so dense as that of the opposite side The dark area is more massive above and measures 6 cm in thickness from the inner table of the skull The remainder of the skull shows quite white by contrast Later, from the pathology seen at operation, one

A



B

FIG 8 (A) Case 3, J B Shows depression and detachment of dura deep into the middle and posterior fossae, irregular destruction of overlying skull and tooth-like projections from inner table (B) Uneven inner surface of bone segment showing bony destruction

could easily explain the physical appearance of the films but could not explain why the destruction of the skull could possibly be produced in the manner observed"

Dr Law and others suggested the possibility of an hemangioma of the skull, and so diagnosed the lesion. Facts revealed at operation did not corroborate any of the pre-operative diagnosis.

Operation—March 5, 1943. Local anesthesia. The patient was placed on his left side and the right side of the head was draped to permit large exposure. As an exploratory measure, for the purpose of obtaining some information about this unusual condition, a burr hole was made through a 1" vertical incision over the center of the defect. The bone was thin, soft and cut easily with the burr. No dura was seen. The opening was slightly enlarged and with this added exposure the following observations were made. There was no tumor so far as could be determined. The dura was depressed, flattened, and at least 32 cm from the inner table of the skull. The extradural space was filled with nothing but air. The appearance of the scalp was normal and there was no escape of air beneath scalp or pericranium. At this point we thought an hemangioma of the skull had eroded into a mastoid cell which connected with the middle ear and permitted escape of air into the extradural space. With this in mind a very large scale flap was marked off and turned down, hinging as low as possible over the ear. The flap consisted of all soft parts including the pericranium. No marking on the outer table indicated the size and extent of the lesion involving the inner table and seen on the radiographs. Therefore, the burr holes were made at points thought and hoped to be beyond the lesion. These were connected by Gigli saw and deVilbiss forceps. A large block of the skull was removed and the area inspected. Below, the involvement of the skull was far beneath the lower margin of the cranial defect created by removal of the bone block. No difficulty was encountered in the removal of this large segment of skull except that the dura was firmly adherent to the skull just at the margin of the defect. It had to be freed by slow, sharp dissection. To our utter amazement, the dura had been stripped away from the inner table deep down in the middle fossa and far back into the posterior fossa. The cerebellar dura was stripped away and exposed for an average distance of about 37 to 5 cm beyond the lateral sinus. The surface of the dura was not only flattened out but was concave (Fig 8a). The lateral sinus was readily identified in its detached depressed position. Its external dural wall was rust colored. It could be traced downward almost to its foramen of exit and back to within about 25 cm from the torcula. The dura was yellow-grey and thickened. The inner table and most of the diploe were destroyed. The outer table was thinned, soft, but not perforated. The area of bone excavation was lined with a pink-red membrane about 2 mm thick. It did not bleed readily. This membrane could be loosened but did not strip off easily. Through this membrane, numerous sharp, fine-pointed tooth-like projections stuck out like spikes. They varied in length from 3 to 7 mm. These white bony points were as sharp as rose thorns. In fact the operator "stuck" one into his gloved finger. These osseous spikes broadened at their base and were continuous with the thinned-out skull. The points were not covered with the membrane. They were glistening white and appeared like little stalactites. The picture seen was aptly described by Wernher¹⁵ in 1873 (and quoted by Woodhall) as a "Reliefkarte eines hohes Alpenlandes" (relief map of the Alpine highlands) Fig 8b. The bony projections in some areas were larger and blunter, especially in the mastoid region. The bone was thinnest in the middle and posterior fossae. The mastoid was excavated with cave-like holes, some communicating with other hollow, dry cavities. It was believed that the air entered the cranial cavity through one of these spaces but none could be identified at the time as to source. (Explanation of entrance of air into the extradural space will be made later.)

In the belief that the membrane lining the bone might be some kind of tumor tissue (hemangioma, etc.) the bone segment, which had been removed, was boiled for about 30 minutes. During this time the remaining involved bone of the middle and posterior

fossae and a portion of eroded inner surface of the mastoid were removed by rongeurs. The bone was soft and friable, "dry" and broke away readily. No air bubbles were seen.

After the bone had been boiled, the membrane could be scraped away, especially after the bony spikes had been removed with rongeurs. The inner table was made as smooth as possible and the segment was "pepper-boxed" with a drill. It was hoped that one would be able to draw the depressed dura, which by this time had become somewhat wrinkled due to expansion of the right ventricle, up to the inner surface of the bone segment and fix it with silk sutures through the drill holes. The dura was picked up in the forceps but it could not be lifted from the cortex. A half-inch incision

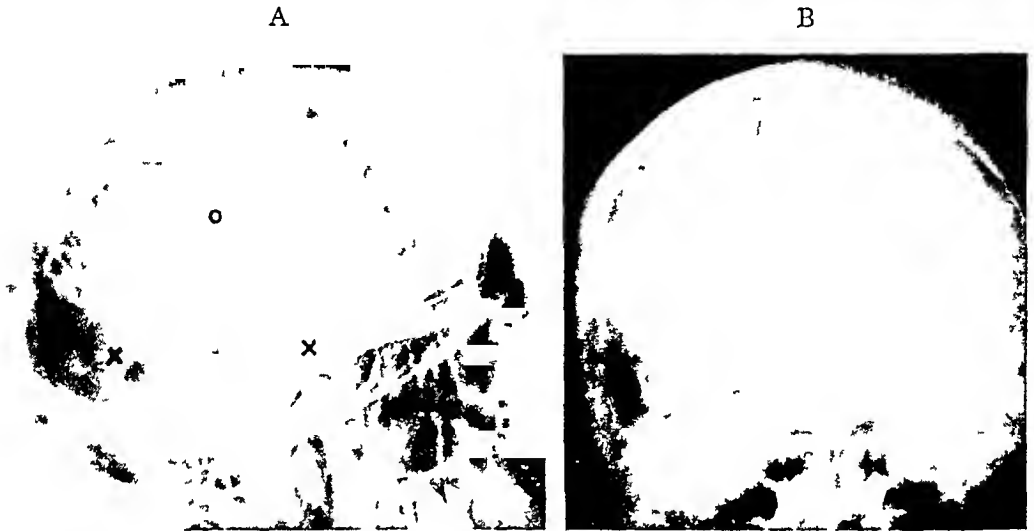


FIG 9—(A and B) Case 3, J B Roentgenograms made on March 15, 1943, 10th post-operative day, o equals bone segment fastened with rustless steel wire x equals skull defects after removal of bone



FIG 10—(A and B) Case 3, J B Photographs of patient on 10th postoperative day

was made in the dura to allow investigation. There were rather large, numerous cortical vessels, and the dura was firmly adherent to them. The dural incision was closed and the attempt to elevate the dura was abandoned for fear of gross damage to the cortex and its vessels.

The bone segment was placed in position and fixed with rustless steel wire, leaving a rather large dead space between the depressed dura and the bone segment. The scalp flap was replaced over the segment and the incision closed in two layers with interrupted silk sutures. A small Penrose drain was placed in the posterior angle of the incision in the hope and with the expectation that a vent for escape of the extradural air might be provided so that the dura could again come into apposition with the skull segment with the expansion of the ventricles. Compression head dressing. Specimen of bone and lining membrane sent to the pathological laboratory.

An infusion given during the operation was suspended and transfusion of blood given. The patient was returned to the ward and, after completion of the transfusion, his condition was good and his lowered blood pressure had increased to 130/80.

Immediate postoperative course uneventful. On tenth postoperative day blood chemistry and roentgen-ray films (Fig 9A and B). Allowed up in chair on the thirteenth day, walked on the sixteenth and discharged on the twentieth postoperative day in "excellent condition" (Fig 10A and B).

Tentative clinical diagnosis—Hemangioma (?) of skull. Pathologic report had not been received.

Pathologic examination—"Acc No 620/43

Clinical diagnosis—Hemangioma of right side of skull

Source—Pieces of bone from lesion of skull

Macroscopic examination—Specimen consists of innumerable small irregular fragments of bony and connective tissue measuring from a few mm to 2 cm across. They are received in formalin and decalcified in formic acid solution. The fragments are derived from (a) skull, (b) dura-like tissue, and (c) scrapings from inside of skull.

Microscopic examination—Small fragments of tissue stained with hematoxylin and eosin consist of fibrous tissue and some fragments of bone. No tumor tissue is seen and no abnormality of blood vessels. In fact, as far as these sections go, the material seems to be normal dura and bone.

Received in Lab 3-9-43. Reported 5-1-43

Dr L D STEVENSON
W C VON GLAHN, M D "

Pathologic examination by Dr A A Eggston¹⁶ revealed that the lining of the inner table consisted of pure fibrous tissue. It probably developed from "islands" of dura remaining after the dura was stripped away from the skull.

Two weeks following his discharge the patient returned and presented considerable bulging of the scalp overlying the defect created by removal of the squama forming the lateral wall of the right middle fossa. The Resident reported this over the telephone to the author who advised aspiration with a large needle, and removal of the fluid which was probably causing the bulge. Aspiration was done, but instead of fluid only air was released. There was no fluid. The bulging mass subsided, but it reappeared. The patient began to drain seropurulent material from a small fistulous tract in the lower portion of the anterior suture line. He complained that when he blew his nose he felt air pass through into the cranium and out through the fistulous tract. This proved to be a fact. Drainage continued, and another small drainage opening appeared posterior in the line of incision in the occipital region. The patient had repeated frontal headaches without dizziness or vomiting. No weakness or disturbance in gait. Hypersensitiveness to loud noises and sudden events. When he held his nose and blew, air bubbles escaped through the two small openings and could be distinctly heard and seen by the examiner. This was definite proof that an intracranial opening existed through which air escaped.

directly or indirectly from the middle ear or Eustachian tube. The original cause of the extradural accumulation of air producing the pneumatocele (and not hemangioma) was now more than suspected,—it was proved.

Inasmuch as the patient's general and local condition were not becoming worse, and believing that infection of the bone block had surely occurred, to be followed by partial or complete sequestration, further operative procedure was deferred.

Re-admission, October 4, 1943, *History* No W-297 and

Physical examination—Blood pressure 140/88. General physical examination re-

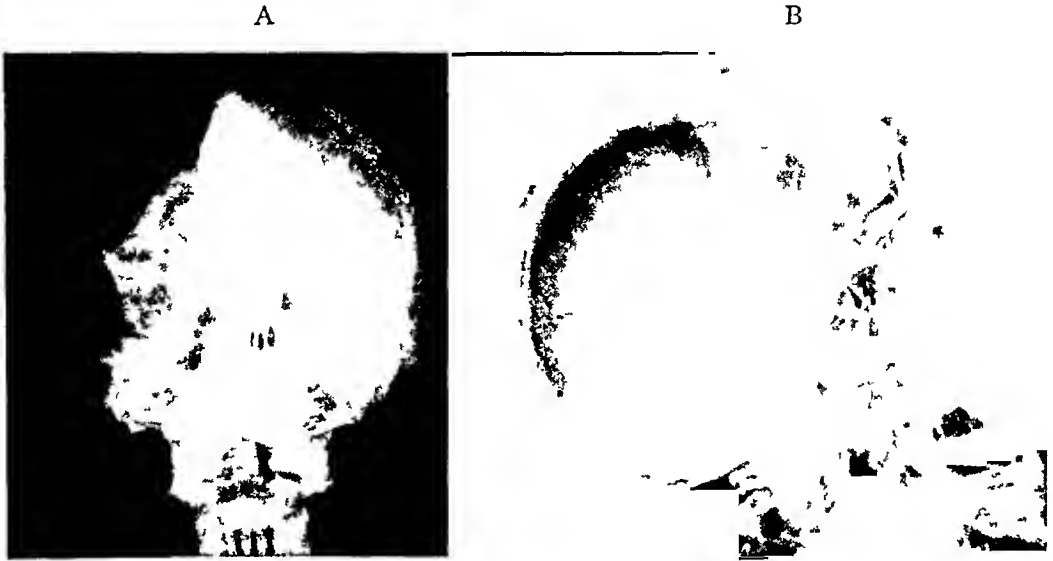


Fig 11 (a and b) Case 3, J B. Roentgenograms made on September 26, 1947—about four years after operation—show reformation of bone, more evident on postero-anterior view.

veals no essential changes except that the patient has a large cranial defect on the right side extending from the anterior frontal region to the occiput, irregular surface—some soft and some resistant—throughout. The two openings of the small drainage sinuses persist.

Fundi show bilateral loss of distinction of disk margins without definite evidence of papilledema. No gross visual defects. Moderate tortuosity and dilatation of veins of the fundus. EOM normal. Hearing slightly diminished on the right side and Weber test lateralizes to the right. Cranial nerves negative otherwise. Gait and station normal. No loss or weakness of motor power. No abnormal reflexes. No sensory changes. Coordination not impaired. Laboratory data negative.

Roentgenographic examination—"Lateral views of the skull reveal a large cranial defect extending from a point 1" anterior to the coronal suture to the occiput and from near the midline, down and into the middle and posterior fossae. The defect is filled with thinned bone, the lower central portion of which appears viable and a coronal margin of bone along the anterior, posterior and superior borders of the defect which appears to be dead and sequestered along a jagged irregular line. The sequestered corona is still fixed to the skull with rustless wire ties. It was interesting to note that the sequestered portion corresponded to that portion of normal bone comprising the upper part of the bone block, while the viable central portion corresponded roughly to the involved excavated portion seen on the films dated 3-15-43. The drill holes in the viable portion are smaller than when made and those in the sequestered portion are larger. The margin of the cranial side has a healthy appearance. No large collection of air is seen.

Antero-posterior view shows the bone block not so much depressed as one might judge from physical examination. The segment is almost on a level with the external surface of the remaining portion of the mastoid. No gross collection of air pockets."

The patient was prepared for operation, with two purposes in mind,—removal of the sequestered portions of the bone segment and obliteration of an tract leading into the mastoid, or middle ear.

Second operation—October 15, 1943. Local anesthesia.

The scar containing the two sinus openings was excised and the scalp flap made at the first operation was elevated and reflected. The central portion of the original segment about 7.5 cm. x 10 cm. was viable and firmly attached to the dura and pericranium. The dural surface, which at termination of the first operation was concave and about an inch or more below the bone segment, now was convex and of normal tension. The sequestered portion of the segment which was fastened to the skull with steel wire ligatures was removed together with the wires. It fitted around the central viable portion like a hood on the head. Other smaller pieces were removed and granulations were gently curetted away from the dura and under surface of the flap. The intact cranial vault was not diseased. There was no osteomyelitis. Attention then turned to the search for the air-fistulous opening. The dura had again become attached firmly at all points from which it had become detached. However, low in the exposure, there was a small funnel-like depression in the extreme tip of which was a tiny pink area about the size of a pin head. It was suspected that this was the opening of the fistula through which air entered the cranial cavity. It was just external to the posterior semi-circular canal, just posterior to the superior ridge of the petrous, and in such position as to connect with the middle ear. It was in no way connected with cells of the mastoid. This funnel-like depression was filled with warm saline and the patient was instructed to "hold your nose and blow." He did, and, sure enough, air bubbled from the small pinhead-sized opening through the saline.

A muscle flap was considered, but in view of the fact that the author had never used one in the presence of infection, and not having read Woodhall's paper, this plan was discarded.

The small fistulous opening was gently curetted with a fine curette, touched with carbolic acid followed by alcohol, washed with saline, and the scalp flap was returned to position and sutured, after placing a small amount of sulfanilamide (the only sulfonamid available in that area, and penicillin was not to be obtained) over the fistulous opening and packing firmly with iodoform gauze. The patient left the table in good condition.

Postoperative course—Dressings were changed daily. Wet Dakin gauze flats and head rolls were used. The proximal end of the iodoform gauze packing was loosened on the 6th day, gradually shortened, and the last piece was removed on the 16th day. The flap healed firmly in position without any collection of air, fluid or pus. The opening from which the iodoform gauze was removed was cored out to about the size of an 18 F catheter, and a small rubber tube was inserted, just within the scalp and fixed with a suture. The purpose of this maneuver was to furnish a vent for escaping air in case the air fistula persisted. He was able to blow air and smoke through this tube, but only with force.

He was discharged on his 28th postoperative day, instructed to return for dressings as needed for the air vent. Should the fistula close, well and good, otherwise, further surgery might be required.

After about two and a half weeks the small tube was removed and the drainage tract closed. There was no further escape of air and no accumulation of air beneath the scalp. The patient returned to work and has been driving a Lexington Avenue bus ever since. On a recent visit to my office he stated that he is in good health, is able to do his work well, and he enters into all activities. His fine head of hair covers a mild

depression of the skull at the site of operation. Only a few areas have not become covered with bone.

Roentgenographic films (Fig 11A and B) reveal a large defect filled for the most part with less dense bone, similar to that observed years after a cranioplasty in which tibio-periosteal transplants were used. The amount of bone present and its position is more apparent on the antero-posterior view. The margins of the defect are smooth and healthy. It is interesting to note that the coral rock appearance has disappeared from the portion of bone segment which remained viable (Compare with Fig 9).

COMMENT

This case of extradural pneumatocele has many interesting features. The air remained confined to the intracranial space and had not quite perforated the skull. There was no air beneath the scalp, as has more often occurred in these relatively rare lesions. The roentgenographic findings, though bizarre, are characteristic and diagnostic. No other lesion produces such a coral rock-like picture. The author has never seen the like. The correct diagnosis was not made. Two noted radiologists, who have seen thousands of skull films, also failed to make the diagnosis because neither had ever seen a case like it. A few months later roentgenograms of a similar case were seen by the three of us and the correct diagnosis was made at once. However, the "coral-rock picture" was not present.

The pathology in the bone results from the air trapped within the cranium between skull and dura. Coughing, sneezing, exhalation, etc force a little more air in without means of escape. Thus the air pocket accumulates.

Traumatic accumulation of air in the brain, ventricles, beneath the skin and in other places are not so uncommon. These conditions are known to all of us.

The author is at a loss to explain the uneven erosion of the skull by the air pressure. Why should the skull be almost completely destroyed in some places and have tooth-like, stalactite-like, sharp, bony projections adjoining the eroded areas? It is believed that air confined exerts equal pressure in every direction, therefore, it may be concluded that other factors influence the erosion of bone. Although the air is confined within a cavity having a rigid wall on one side and a mobile pulsating wall on the other, it is difficult to understand how this fact would influence the unequal destruction of bone. Eggston and Wolf¹⁷ who included a radiographic print of this case in the recent monumental text "Histopathology of the Ear, Nose and Throat," suggested that it is due to some chemical change in the bony structures of the skull by the pressure of the confined air.

On the other hand, firm fixation of the dura to the depressed cortex and cortical vessels can logically be expected following prolonged compression of the structures. It could be assumed that adhesions would form after these structures had been compressed for a long period with the added trauma of 4320 pulsations of the brain per hour.

It is not advisable to attempt to fix the dura to the bone. Separation of the dura from the large cortical vessels might produce irreparable damage.

Also it is not necessary, as proved by this case. Closure of the opening of the an fistula by means of a muscle-fascia flap was considered. It was recalled that Eggers,—and later Shenstone, had advocated a similar type of flap for closure of a bronchial fistula and had used it successfully. Since that time, many surgeons have carried out this procedure with equally good results. However, a muscle-fascia flap was not used in this case on account of the gross infection already present and the possibility of continued infection through the fistula leading into the middle ear. At the present time, when all of the sulfonamides and penicillin are universally available, the transplant-muscle-fascia flap on both should certainly be used.

Following operation the patient should be placed flat in bed, active administration of fluids should be carried out, and lumbar puncture should not be done. With this routine, the depressed dura will rise and come into contact with the skull through expansion of the ventricular system, provided a vent is established via a small rubber tube placed in the lower angle of the incision for 36 or 48 hours. It is important that all the sharp, tooth-like bony spikes be removed from the inner table, otherwise, these certainly would be thrust or driven through the expanding elevated dura-like "die eiserne Jungfrau."

The author has repeatedly regretted that he had not read Woodhall's and Baker's paper before he saw the radiographic films of the skull in this case. The final result obtained was good, but the patient would have been spared many days of hospitalization, a second operation, and the loss of many working days had the fistulous opening been found at the first operation and closed by a fascial graft, muscle-fascia flap, or both.

Case 4—Manhattan Eye, Ear and Throat Hospital, Ear and Throat Clinic, No E 36857. Pneumatocele, fronto-temporary-parieto-occipital. Diagnosis made. Operation deferred. Preliminary report.

Mrs. E. V. Age 38, white, female, housewife. Weight about 112 lbs. Examined in office, December 2, 1947.

Past history irrelevant other than for the fact that she had the usual childhood diseases including diphtheria.

Present illness—About the middle of November in 1944 she had a cold for about three weeks and was referred by her family physician to Dr. M. Pullen. She complained of a "feeling of fullness" and loss of hearing in the right ear. No history of injury. When the cold cleared up her hearing was normal again. Dr. Pullen stated that the only abnormal finding at the time was a marked redness and injection of Shrapnel's membrane on the right. A few days later she was referred to Dr. F. M. Law for roentgenograms of the skull. At this time the unusual features of the roentgen films were first noticed. She has had no complaints or difficulties of any kind except, with an occasional cold, she has diminished hearing in the right ear, which clears up with the recovery from the cold. No headaches, no dizziness, no noises in the ear, no diminished vision. In other words her history is completely negative except for a few colds.

Appearance—Apparently she is a perfectly normal woman in every respect. She is bright, intelligent, and gives no sign of any kind referable to the lesion seen on the roentgen-ray films. All cranial nerves are negative except for a slight peripheral right facial.

Motor and sensory—Both intact No areas of hypesthesia, no motor weakness
Deep reflexes—All present Left upper abdominal diminished Knee jerks somewhat increased on the left Ankle jerks same No Babinski

Mouth—On the external surface of the alveolar process on the right side there is an osteoma which has been present for about 5 years It has barely increased in size since first noticed by the patient It is not painful Some thickening of the alveolar process on the left side also, but no definite osteoma There is slight asymmetry of the face The right side of the cheek is somewhat more prominent than the left, due to the osteoma of the alveolar process of the right side of the maxilla

In other words, a patient who, with the exception of a few changes in her deep reflexes, is without signs or symptoms, and none commensurate with the large defect shown on the last roentgenographic film

Roentgenographic findings—M 2309, 12-15-44 *Lateral view* (Fig 12a) There is

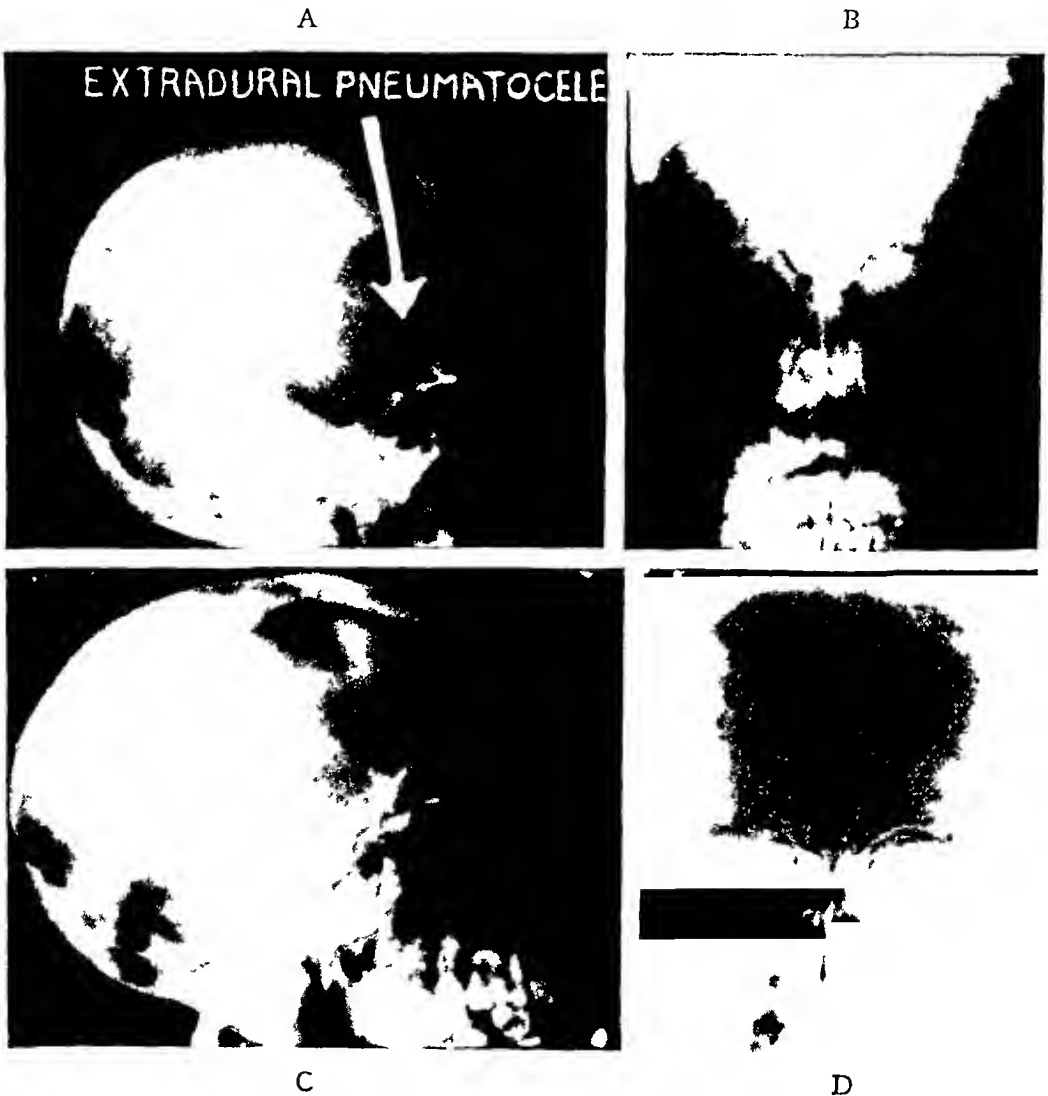


FIG 12 (A, B, C and D) Case 4, E V Roentgenograms of skull showing extradural pneumatocele (A) Lateral view showing size of defect, December 15, 1944 (B) Postero-anterior, December 15, 1944 (C) Lateral view, June 4, 1947 shows marked extension in all directions, including posterior fossa (D) Postero-anterior, June 4, 1947 showing extension of lesion upward and to the left over frontal sinus

a cranial defect 11 cm in the longitudinal direction and 7 cm in the vertical direction involving the fronto-temporal region, extending from the inner table of the skull over the frontal sinus backward in an angular fashion at a point directly over the petrous. It extends upward in the frontal region to within $3\frac{1}{2}$ cm of the inner table of the skull in the mid-frontal region along the vertex. It extends downward into the middle and anterior fossae, with gross destruction of the bone. There are a few remnants of bony streaks remaining, apparently in the subperiosteal position. The right sphenoid ridge is partly destroyed. There is some bone absorption of the entire sella. The margins of the defect are somewhat scalloped, but not to the same degree as in Case 3.

Postero-anterior view (Fig 12B) reveals marked destruction of the petrous pyramid on the right side with but little change in the pyramid on the left side. The orbital ridge is more distinct on the left than on the right. The floor of the middle and anterior fossae is not destroyed. The dehiscence in the bone which might indicate the opening of the air fistula cannot be detected.

11-14-45 (M-6251) *Lateral view*—The cranial defect is quite similar to the one shown on the previous films. However, it has extended farther toward the vertex. The normal bone measures $2\frac{1}{2}$ cm wide above the defect in the frontal region. Over the extreme anterior portion there is some accentuation of skull destruction. The posterior wall of the right frontal sinus is very thin being scarcely perceptible, and there is a possibility of a dehiscence in it. The destruction of the floor of the middle fossa has increased slightly. The remaining portion of the wall of the glenoid fossa is thin. Backward extension of the lesion has not increased over the petrous.

Postero-anterior view—Extension upward of the lesion can be seen. Destruction of the right petrous is greater above than before. Destruction of the left petrous is about the same as in the preceding view with some increased pneumatization of the apex of the left petrous.

E V 11-4-46 (N 963) *Lateral view*, (almost a year later), shows marked extension of the pneumatocele, especially backward. It extends now over the top of the petrous into the posterior temporal region and far back into the suboccipital region,—almost to the torcula. There is greater destruction and pneumatization of the petrous pyramid. The floor of the glenoid fossa is thinner. The base of the skull anterior to the fossa is depressed downward and appears to be destroyed. There is greater destruction of the bone forming the right orbit. The posterior and anterior clinoids are less dense. The defect extends farther upward toward the vertex, and the frontal bone above the frontal sinus is markedly thinned out as compared with the last film. The scalloped border is more accentuated. The defect measures 17 cm in a line from a point above the frontal sinus downward and backward into the suboccipital region and about 10 cm in the vertical direction.

Postero-anterior view—Greater destruction of bone behind the orbit is seen and marked absorption of bone from the supra-orbital ridge. The pneumatocele now extends across the mid line above and behind the right lateral sinus. There is greater absorption and pneumatization of both the right and the left petrous pyramid, more marked on the right.

E V 6-4-47 (N 4251) (seven months later) *Lateral view* (Fig 12c) shows extension of the lesion backward, forward and downward into the posterior fossa. In stereo, the petrous pyramid stands out like a bony crag. The defect extends to within 8 mm of the inner table of the skull above. The floor of the glenoid fossa is almost destroyed. There is greater thinning of the frontal bone just above the frontal sinus and there is a questionable defect in the posterior plate of the right frontal sinus. There is still greater absorption of the right sphenoid ridge and the right orbital margins.

Postero-anterior view (Fig 12d) shows the pneumatocele has extended even more toward the left and higher behind and above the frontal sinuses. The floor of the middle

fossa is more thinned out. The sphenoidal ridge is barely perceptible. There is greater destruction of the bone forming the outer half of the orbit.

The condition was explained thoroughly to the patient. She understood the possibility of perforation of the skull with extension beneath the scalp. She was not frightened. Should this complication develop, she will return for operation.

COMMENT

The position of the internal opening of the air fistula is not known. It can be determined only by operation. It is almost inconceivable that such a large extradural pneumatocele could develop with so few signs or symptoms. If and when this patient comes to operation, the findings will be reported.

The subject of pneumatocele was ably presented by Woodhall and Baker in their paper published in 1941. They reviewed the previously reported cases and gave a detailed report of a most interesting personal case. The case of Woodhall and Baker presented a communicating pneumatocele with the intracranial extradural pocket connecting with one beneath the scalp through an opening in the skull. Doubtless, if roentgenographic films had accidentally been made before perforation of the skull had occurred, the same or similar characteristics of a skull defect as shown in the author's two cases would have been noted. Woodhall and Baker did not locate the exact point of entrance of air into the extradural space, although they thoughtfully filled the suspected area of the cavity with warm saline hoping to find the "definite point of entry for the air." They observed "several small apertures passing, in all probability, into the mastoid antium," and filled these tiny areas with bone wax. They placed a free fascial "transplant"—not a flap of muscle and fascia—over the defects previously filled with wax and brought the depressed dura up over the transplant and fixed it in position with fine black silk sutures. In this manner at one sitting they thoroughly and completely closed the opening through which the air had gained entrance to the extradural space. The patient made an uneventful recovery and was discharged on the eighth postoperative day. Their review of the literature is adequate and will not be repeated.

In a paper published in 1945 Woodhall and Cramer¹⁸ reported a case of pneumatocele with a tantalum plate which had been used to close a traumatic defect in the frontal region. Air had found its way up through a fistulous tract from the fronto-ethmoid region filled up the entire area. They located the point of entrance of air, successfully closed the opening with a transplant and flap, replaced the tantalum plate, and the patient recovered without reaccumulation of air.

Further review of the literature since 1944 fails to reveal reports of cases similar to those described in this paper. Imperfection of the indices for the last two years may have resulted in failure to recognize similar case reports.

SUMMARY

The characteristic features of cranial defects produced by diploic extradural pneumatocele have been described. The destructive lesion results in a

defect so typical in character that diagnosis should be made before operation

Where the epidermoid involves the cranial vault, the entire tumor mass should be removed including a segment of bone with the viable portion of the tumor attached so as to prevent recurrence. Where necessary, the dura should be resected, with the same objective in view, followed by fascia-lata transplant for the dural defect.

If the dura is not resected, curettage, boiling of bone segment and replacement are advocated. When the dura is resected, replacement of the bone segment should be deferred for several months in larger defects. Smaller ones do not require cranioplasty.

In cases of extradural pneumatocele, the involved segment of bone should be resected and the bony spicules should be removed. The intracranial extradural opening of the air fistula should be found and closed with a fascial transplant or muscle-fascial flap. Penicillin and sulfanamide should be administered. Operation should be done before spontaneous perforation of the skull occurs.

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DISCUSSION —DR R E SEMMES, Memphis, Tenn In addition to the interesting material Doctor King presented I was gratified to note that I could still understand him He has been out of Tennessee for a long time but you can realize that he is still not a Yankee

Doctor King has encountered some remarkable material I would like to mention some other lesions which involve the skull that also show little or no bone reaction particularly mucocles, cholesteatoma and epidermoids, which would be difficult to distinguish from the conditions he has shown

DR JOSEPH E J KING, New York (closing) I shall make no further remarks other than to present some lantern slides sent me by Dr Barnes Woodhall, who could not be present due to illness in his family These are slides of his case reported in his paper of May, 1941

The condition found was very similar to my first case of pneumatocele, the main difference being that the skull had become perforated in his case, followed by a large collection of air beneath the scalp Doctor Woodhall concluded his report as follows "The patient's postoperative course in the hospital following operation was uneventful and he was discharged on the eighth postoperative day No recurrence has been reported to date, although it must be admitted that, possibly in the exuberance following recovery the patient committed mayhem on a neighbor, and has not been seen since, six months after the operative procedure"

ANATOMICAL OBSERVATIONS ON THE LUMBAR SYMPATHETICS WITH EVALUATION OF SYMPATHECTOMIES IN ORGANIC PERIPHERAL VASCULAR DISEASE*

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THE DEGREE OF SUCCESS attained in the treatment of peripheral vascular disease depends upon the ability to overcome vasospastic factors

Leriche indicated that in peripheral vascular disease spasm is the controllable factor, and that if collateral circulation is to be readily established, there must be no vasoconstrictive influence affecting the peripheral collateral network

Although Claude Bernard discovered vasomotor nerves in 1851, and Jaboulay directed attention toward the role of sympathetic surgery in the late nineties, interest evoked was negligible until about 1925. The work of Royle and Hunter, in 1924, was particularly noteworthy in directing attention toward surgery of the sympathetic nervous system. Since that time, appreciation of the role of the sympathetic nervous system has gradually increased. Concurrently, there has developed an increasing interest in the problem of peripheral vascular disease. The intimate inter-relationship of the two systems, both functionally and pathologically, has become well recognized. Certain clear cut concepts regarding the sympathetic system have emerged. Concepts regarding vascular disease have not been as well delineated.

In the final analysis—this diversity exists not because of differences in interpreting the underlying vascular lesion, but because of variables in the therapeutic approach to associated factors of which the sympathetic nervous system is of prime importance.

Disturbance in the normal amount of circulating blood in peripheral vascular disease is dependent upon two factors, either or both of which may be present: (1) obliterative structural change, (2) abnormal spasticity. In spastic conditions, belonging in the category of Raynaud's disease, that fail to respond to conservative therapy, sympathectomy remains the procedure of choice despite occasional disappointing recurrences. In addition, the importance of sympathectomy in thromboangitis obliterans seems to be well recognized and generally accepted. However, considerable difference of opinion exists regarding the rationale of sympathectomy in degenerative vascular disease.

Alteration in the blood supply to tissue is an inevitable process of body involution. It is one phase of our biologic heritage. When certain tissues become involved, out of all proportion to the remainder of the body, physiologic and functional derangement is the inevitable consequence.

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Wednesday, December 10, 1947.

Well selected cases of occlusive arterial disease uniformly show a satisfactory response to ganglionectomy. These patients, however, should be subjected to such a procedure only after cautious evaluation, and after it has been determined that conservative therapy will not accomplish the degree of improvement anticipated by ganglionectomy.

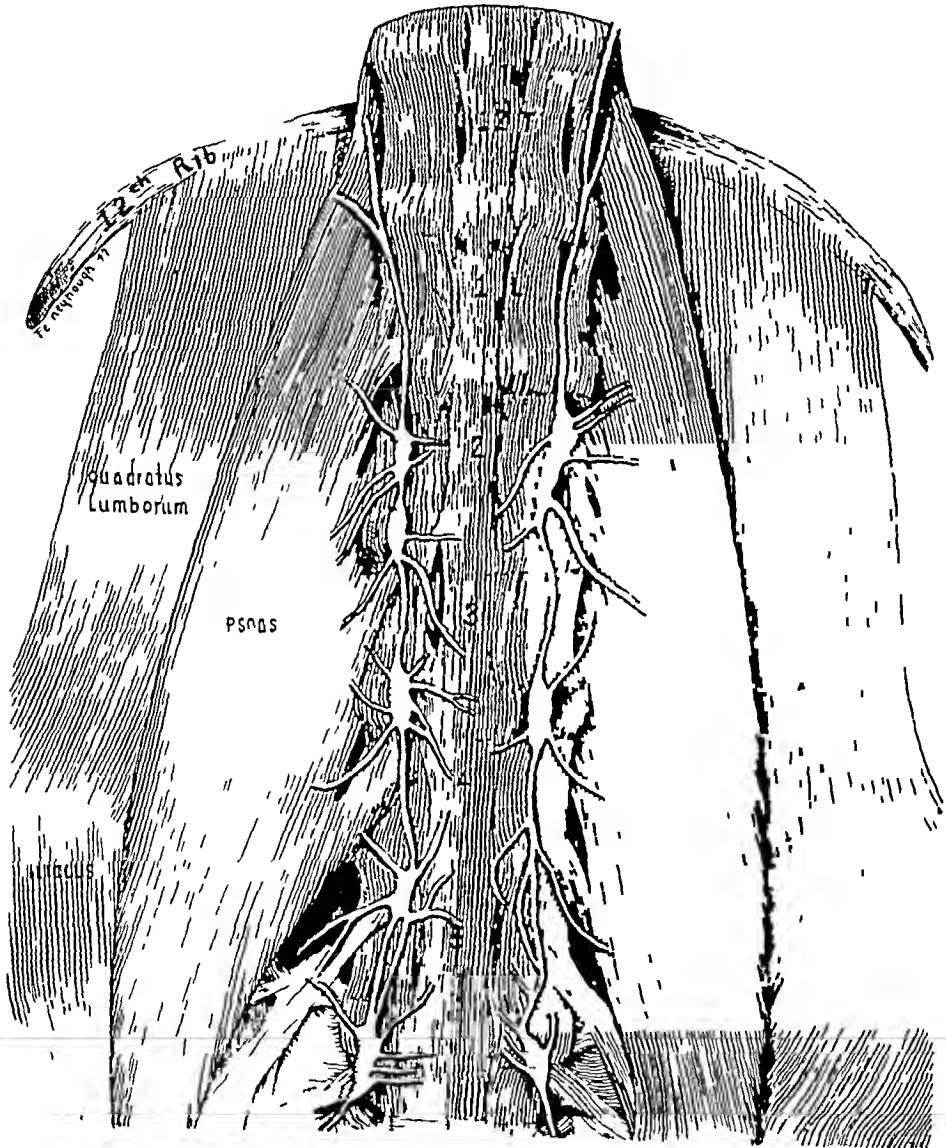


FIG 1—Lumbar sympathetic system, Joseph Swan, 1825

Sympathectomy reduces the potential pathologic vasoconstriction of the individual, without abolishing physiological power. Theoretically, all cases of peripheral vasospasm should be relieved by sympathectomy. Clinical and laboratory observations, however, have confirmed the impression that there are several types of vasospasm and that the autonomic nervous system does not completely control the dilatability of the peripheral arterial system.

As early as 1919, Leriche, in his monographs, made the statement that

he intervened surgically in cases of senile arteritis at the earliest possible moment. He advocated periarterial sympathectomy, arteriectomy or lumbar sympathectomy according to the particular case. The latter operation, which is based on sound anatomic and physiologic considerations, has gradually become accepted as the procedure of choice.

In this clinic, sympathectomies in degenerative organic vascular disease

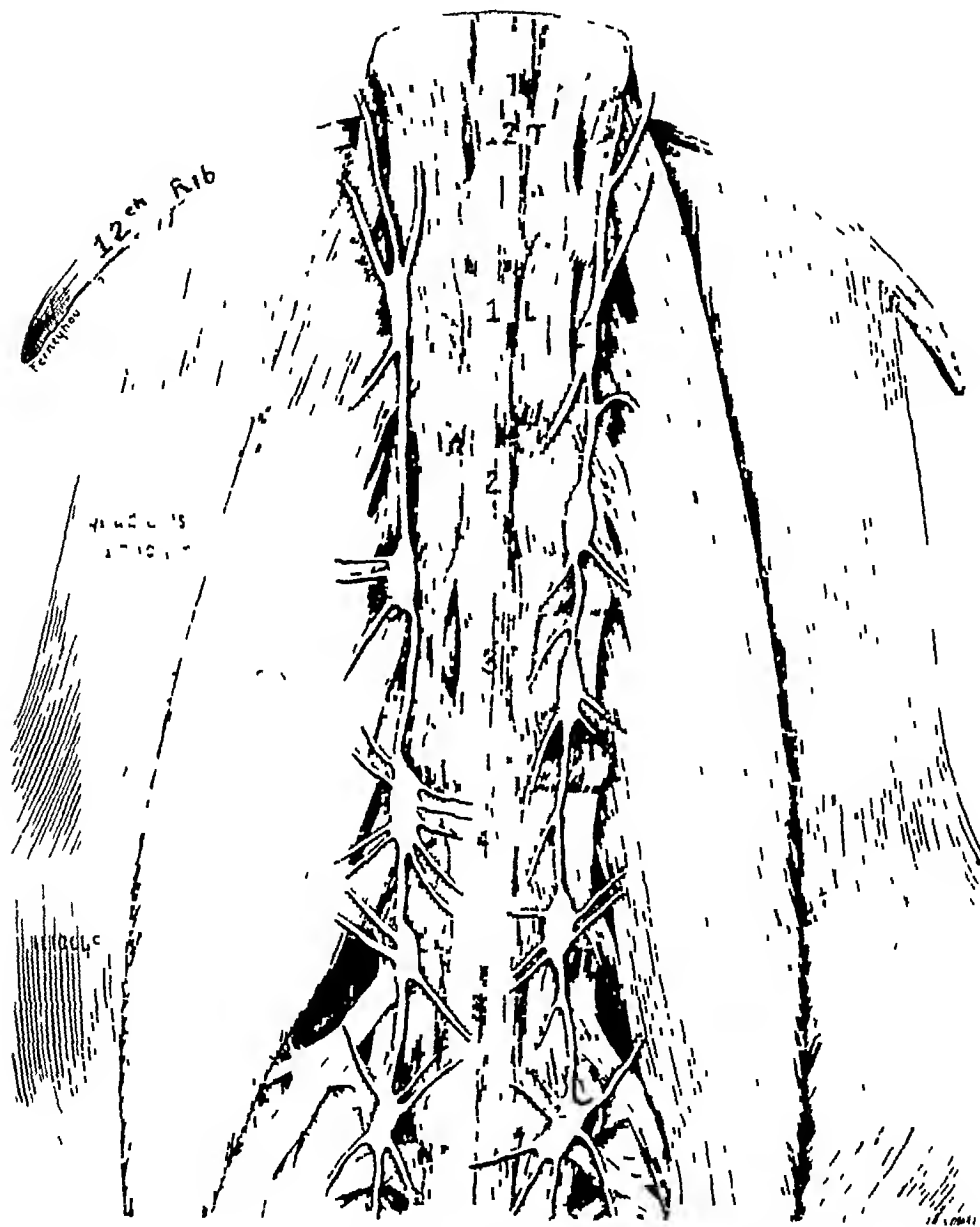


FIG 2—Lumbar sympathetic system, Ludovic Hirschfeld, 1866

have been performed since 1939. The operation is now limited to those patients with demonstrable associated vasospasm, not responding to conservative measures, including such procedures as paravertebral blocks. In this study, a total of 150 patients have had either single or bilateral lumbar ganglionectomies.

*Case Reports from University Hospital, Baltimore, Maryland, and the Baltimore City Hospitals, Baltimore, Maryland

Analysis reveals that 46 patients (30.66%) were discharged from the hospital as "improved." An additional 12 patients presumably had lumbar ganglionectomies performed. Pathologic examination of the tissues from this group did not reveal evidence of sympathetic nerve tissue or ganglion, and therefore these patients were not included in this study. A requisite for inclusion of the 150 patients studied in this group, was pathologic confirmation

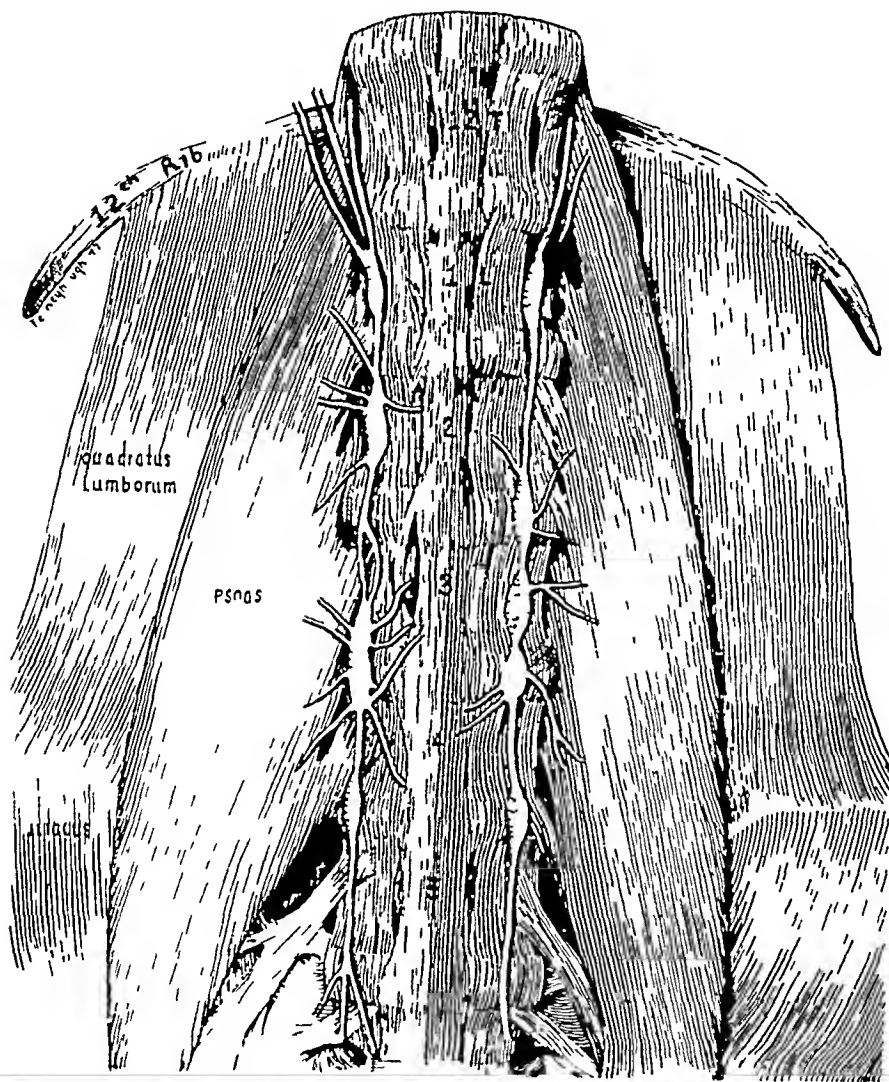


FIG 3—Lumbar sympathetic system, A Hovelacque, 1927

- of sympathetic nerve tissue and ganglion. It is believed that with the exception of one case noted below, removal of tissue not consisting of the sympathetic chain represented unfamiliarity with its variations, rather than congenital absence. In a few instances, it was difficult to evaluate the degree of improvement and whether or not it was attributable to the ganglionectomy itself, or to hospital adjunctive care, and restriction of activities. Follow-up revealed recurrence of symptoms in 6 months to one year in ten cases, of such degree

as to require adjunctive therapeutic measures. These results are somewhat disappointing. However, it is believed that additional analysis will reveal that many of the disappointments were due to controllable factors, and were not related to the rationality and efficacy of sympathectomy.

Sympathectomy in degenerative obliterative vascular disease is usually advocated for one or several of the following reasons: (a) Relief of pain and

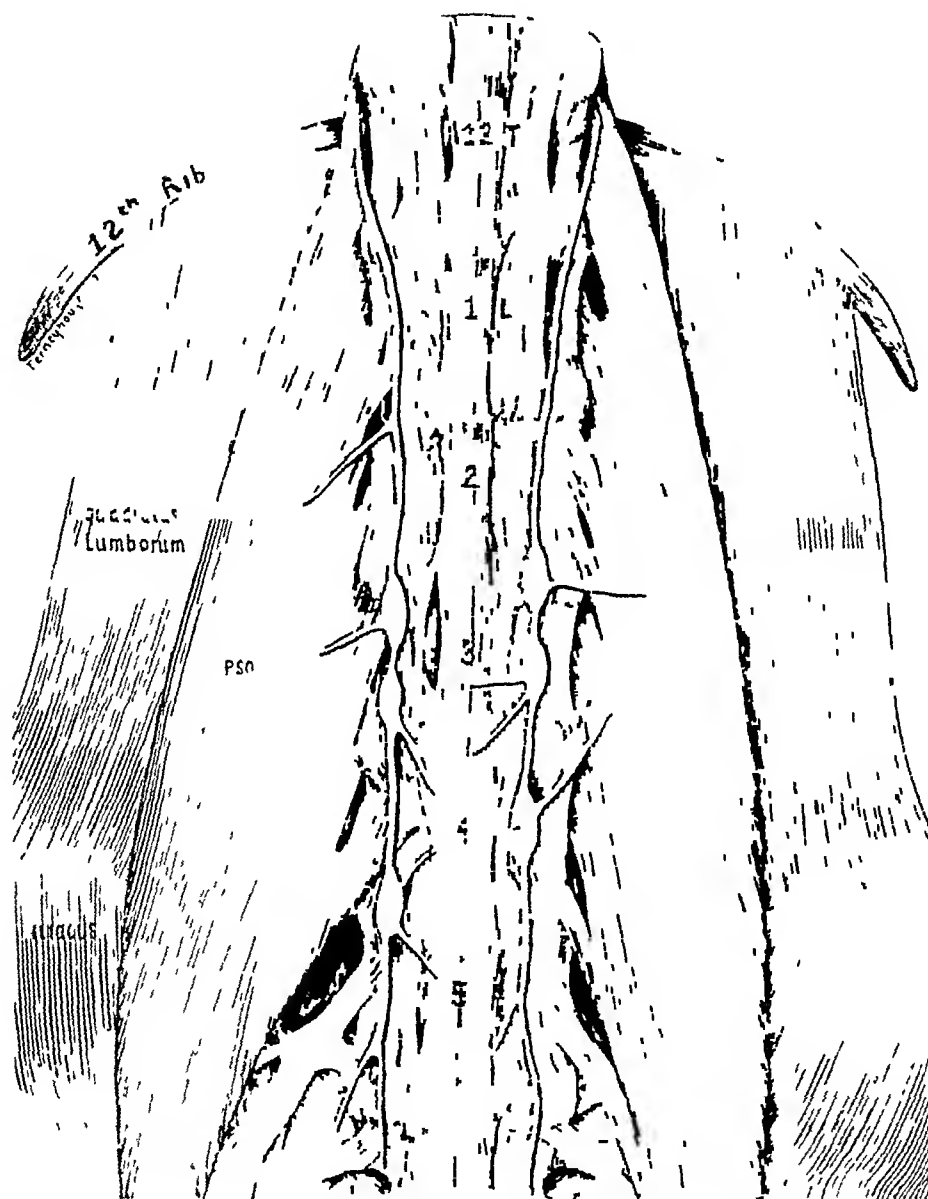


FIG 4—Case 8. No ganglion on either side of L-1 and almost all of L-2. Three ganglia appear on either side, below the level of the intervertebral substance of L-2 and L-3.

improvement of collateral circulation, (b) Avoidance or postponement of amputation, (c) Extending the safe level in cases of inevitable amputation, (d) Simplicity and ease of performance.

RELIEF OF PAIN AND IMPROVEMENT OF COLLATERAL CIRCULATION

In our experience, relief of pain is unpredictable. In vasomotor disturbances, spasm is a major pain factor. Studies should always be made to differen-

tiate the degree of organic occlusion and associated vasospasm. This is important, in order to establish whether or not the procedure is warranted, whether there is a reasonable chance of relieving pain, and as a prognosis index. In this series, it was noted that only 77 of the 150 patients had what are considered minimal vasomotor studies. In other words, 73 patients had



FIG 5—Case 11. Four ganglia more or less symmetrically placed on the two sides, and in corresponding relationship to the lumbar vertebrae. Frequently, this is thought to be the usual arrangement, but in this series of dissections it was the least usual.

ganglionectomies without adequate vasomotor studies. This represents a rather poor selection of cases. It is realized that the procedure was advocated in an effort to improve an apparently hopeless condition. However, to avoid casting doubt on an otherwise effective procedure, it should be reserved for those cases in which there is reasonable chance of success.

Sympathetic novocain block was performed on 77 patients of the 150

patients in this series, and an attempt was made to evaluate the possible effects of ganglionectomy. No attempt was made to establish a real criteria for the operation in 73 cases. Although sympathetic procaine block will not always give reliable information regarding the probable results of sympathectomy,

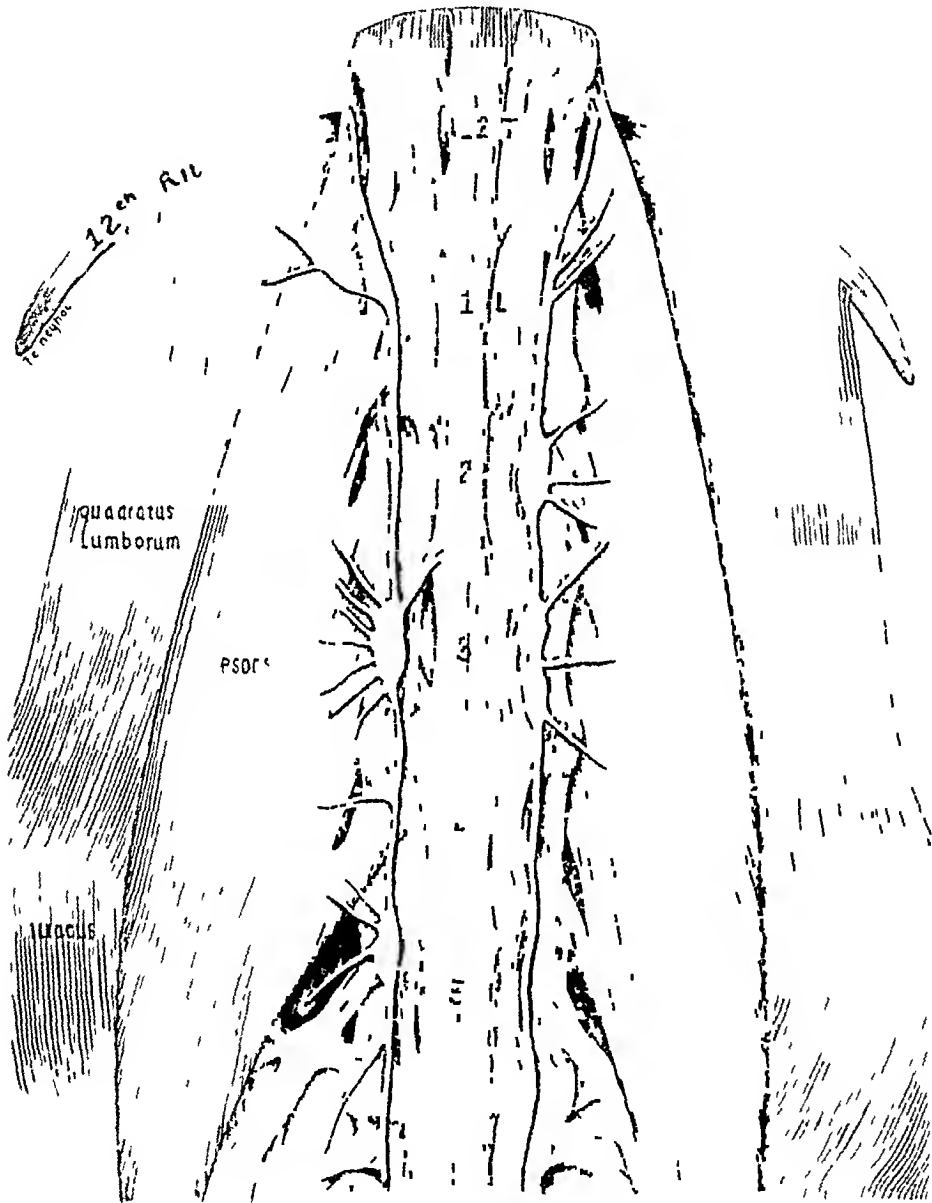


FIG 6—Case 12 No ganglion overlying L1 on either side, no ganglion below the level of L3 on the left

tomy, it is believed, that it, or its equivalent, should be employed as a basis of evaluation. If positive evidence is not gained, it may at least give a negative type of evidence, as demonstrated by temperature drop. De Takats has indicated that digits revealing temperature drop, may become gangrenous following sympathectomy.

Efficacy of sympathectomy in correcting ischaemia, depends upon the capacity of the collateral circulation to improve, by elimination of persistent or intermittent vasoconstriction and maintenance of vasodilatation.

Gask and Ross pointed out that "if after sympathectomy a considerable degree of tonus appears in the denervated vessels, the condition of the patient may be more precarious than it was before the operation, since the vessels are no longer under the control of the nervous mechanism. It is



FIG 7—Case 13. Rami radiate in all directions, communicating rami from 2nd ganglion on left fuses with common trunk. Note well defined communication between right and left trunks, at the level of the 3rd and 4th intervertebral substance. This is not an unusual occurrence.

believed that vasomotor nerves exhibit the phenomena of reciprocal innervation, vasodilatation involving an inhibition of vasoconstrictor tonus.'

AVOIDANCE OR POSTPONEMENT OF AMPUTATION

Fifty-six patients required amputation of varying degrees, 13 involving the foot or less, and 15, of the leg, below the knee. Twenty-eight amputations were supracondylar in character. Six patients had bilateral amputation

All of these amputations were performed within two months following ganglionectomy.

EXTENDING THE LEVEL OF INEVITABLE AMPUTATION

The average amputation age was 56.8 years. The average age for the entire series was 52.5 years. Fifty per cent of the amputations performed were supracondylar in character. With advanced organic degeneration, slight vasospasm and loss of elasticity of collateral vessels, it is not probable that sympathectomy will extend the level of safe amputation, any more effectively than general supportive measures.

SIMPLICITY AND EASE OF OPERATION

There were nine deaths under 10 days, a mortality rate of 5.5%. There were eight additional deaths within 30 postoperative days. All operations were of the retroperitoneal type. In one patient not included in this statistical study, the ganglionated chain could not be identified due to extensive inflammatory changes. These changes were apparently secondary to repeated paravertebral blocks. Pathologic examination of tissue removed from an additional 11 patients, also not included in this statistical study, revealed either lymphatic or fibrous tissue and not sympathetic nerve tissue. These findings do not tend to confirm the statement that has been made that lumbar ganglionectomy should be performed in questionable cases because it is a comparatively simple and easy type of procedure.

This report represents the collective efforts of various surgical residents, as well as visiting surgeons. In attempting to evaluate the end results, individual variations in technic and incompleteness of operation may account for some of the disappointing results. Also, unless there is an awareness of the extremely varied characteristics of the lumbar sympathetics, portions of the chain will frequently be overlooked.

In attempting to clarify the indications for sympathectomy, and to simplify the operative problem, proper attention has not been focused on these variations and the criteria for adequacy of operation. Access to, and adequate exposure of an anatomic structure, is but one phase of the important problem of surgical attack on the structure itself.

The lumbar sympathetic chain usually is diagrammatically represented by a ganglion resting on the body of each of the first four lumbar vertebrae on the right and left sides. Discussion is frequently limited to the chain's relationship with the vena cava and aorta respectively. In our experience, the lumbar sympathetic chain has proven the most variable portion of the sympathetic system, and one of the most variable structures in human anatomy.

Swan, in 1825, indicated that on the right side, the first lumbar sympathetic ganglion appears at the level of the beginning of the second lumbar vertebra, the second ganglion at the lower part of the second lumbar vertebra, the third ganglion between the third and fourth lumbar vertebrae, and

the fourth ganglion between the fourth and fifth lumbar vertebrae. On the left side, he stated that there were but two ganglia, the first ganglion located as on the right, while the second ganglion appears over the upper part of the fourth lumbar vertebra.

Hirschfeld, in 1866, showed four ganglia on each side, with the fourth



FIG 8—Case 14. Large rami coming off the sympathetic chain without presence of ganglia, over region of 4th lumbar vertebra. This is not an unusual occurrence.

ganglion appearing on the upper part of the body of the fifth lumbar vertebra.

Hovelocque, in 1925, placed the first lumbar ganglion, on the right side, on the body of the first lumbar vertebra, the second ganglion on the middle of the second lumbar vertebra, with three cephalad and one caudad rami, the third ganglion on the lower half of the third vertebra and intervertebral substance, and the fourth ganglion on the intervertebral substance of the

fourth and fifth lumbar vertebrae In his illustrations, he shows four ganglia on the right and five on the left

Pearl, in describing a muscle-splitting extraperitoneal lumbar ganglionectomy, makes the statement that the rami of the second ganglion are directed

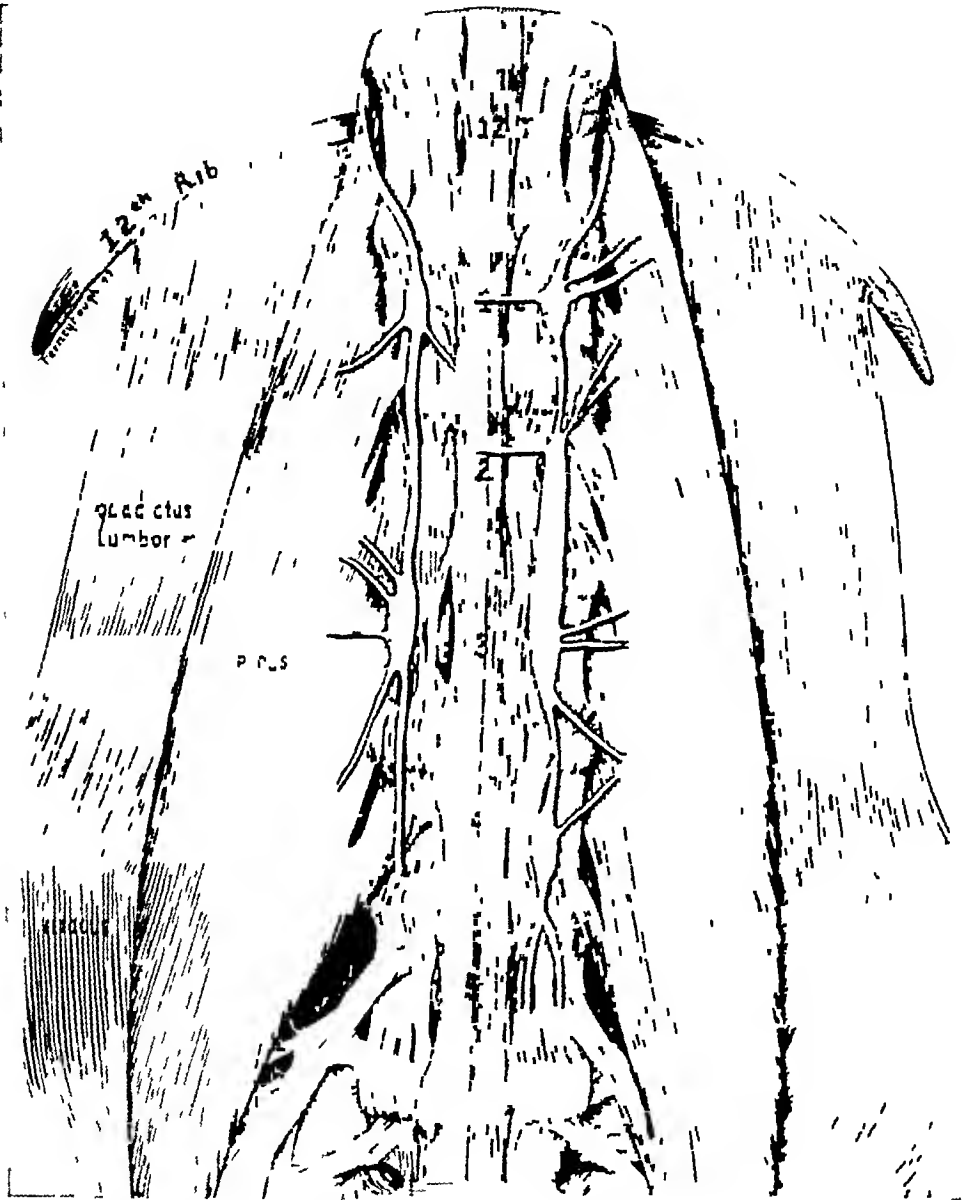


FIG 9—Case 17 Single ganglion present, 1st L vertebra, right and left sides, frequently they are absent, and one sees only the thoracic trunk passing from lateral to anterior with a communicating branch The large elongated ganglion on the left covers nearly all of lumbar vertebrae 2 and 3

cephalad, whereas those of the third and fourth ganglia are directed caudad or transversely

Livingston, in 1937, expressed the opinion that variations in the lumbar region are so common as to render it almost absurd to state that "the second, third and fourth lumbar ganglia were removed" He states that, what is meant, is that the surgeon removed as much of the chain as he could conveniently get at, from as near the usual location of the first lumbar

ganglion to the point where the chain passed beneath the iliac vessels into the pelvis

Atlas states that "because of erratic fusion of lumbar sympathetic tissue, it is impossible to designate lumbar ganglia on a numerical basis with any degree of accuracy" He also states that "because of unpredictable varia-

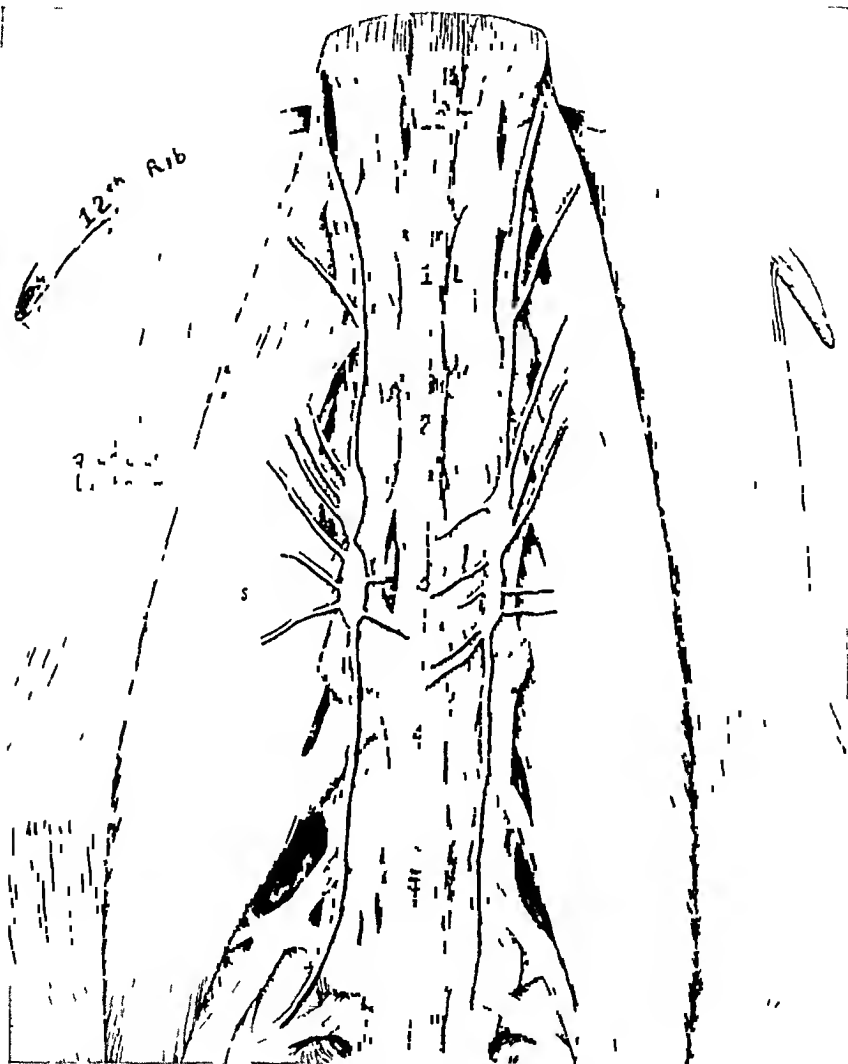


FIG 10—Case 18 Ganglia fused, two on each side

tions in the number and position of the lumbar sympathetic ganglia, it is preferable to describe a lumbar sympathectomy not on the basis of which ganglia were removed, but from the anterolateral surfaces of which vertebral bodies the trunk was resected"

Gask and Ross state, "there are four lumbar ganglia, and as the fourth usually lies on the pelvic brim behind the common iliac vessels, it is not removed in the operation commonly practised for sympathetic denervation of the leg" They believe, "the sympathetic supply to the leg has its con-

nector cells in the lowest three thoracic and the upper three lumbar segments, the preganglionic fibres passing out in the six lowest white rami communicantes, and ending in the second, third and fourth lumbar, and in the sacral ganglia. The grey rami communicantes from the second lumbar ganglion downwards contain postganglionic fibres which are carried to the periphery by way of the lumbar and sacral plexuses of the spinal nerves. It is therefore clear that if the second, third and fourth ganglia and the intervening portions of the trunk be removed, the excitator cells to the lumbar nerves and the preganglionic fibres to the sacral nerves will be removed or divided, and sympathetic denervation of the leg will thus be achieved."

Lumbar sympathectomy, for effectiveness, should be physiologically, as well as anatomically complete, and at the same time not be associated with unpleasant complications. J. C. White has shown that bilateral resection of the first lumbar ganglion is usually followed in male subjects by paralysis of the ejaculatory mechanism and sterility. In cases of simple vascular spasm this ganglion should be spared.

Livingston feels that the third lumbar ganglion is the "central point" for surgical attack, while Atlas believes that if incomplete denervations are to be consistently avoided, the exposure of the sympathetic trunk should be carried as high as the intervertebral disk between the second and third lumbar vertebrae before the trunk is divided and stripped.

The latter also believes that if the sacral ganglia are left undisturbed, a predominantly preganglionic denervation of the blood vessels of the foot is obtained. Sensitization of arteriolar musculature to circulating adrenaline which follows destruction of its postganglionic innervation is thereby avoided, and the denervated arterioles in the foot remain dilated. Since preganglionic fibers rarely join the sympathetic trunk below the level of the second lumbar vertebra, the simple maneuver of dividing the trunk at the upper pole of the third lumbar vertebra interrupts the flow of vasomotor impulses to those blood vessels of the lower extremities which receive their innervation through the branches of spinal nerves L 3, 4, 5, S 1, 2 and 3.

In a series of 19 anatomic studies, we could not find a sympathetic ganglion on the first lumbar vertebra on the right side in nine instances, and on the left, in six instances. A ganglion was not found on either side of the first lumbar vertebra in four instances. The number of lumbar ganglia found ranged from two to five, the average number of ganglia on each side being about three. The rami to a ganglion varied from two to seven, dissections were gross in character, and it is probable that smaller filaments were destroyed without identification. In the entire series, no two chains were similar, and no pattern of variation could be established. There were no predominant characteristics for either sex. The age range studied was from a stillborn male to an 83-year-old female.

The direction of the rami for individual ganglia varied from cephalad, and transverse to caudad. In our opinion, identification of an individual ganglion

by direction of its rami is unreliable. Lumbar veins passing anterior to the sympathetic chain were an infrequent occurrence.

The most constant ganglion, on both the right and left side, was found on some portion of the second lumbar vertebra, usually its lower third, and frequently crossed the intervertebral substance on to the body of the third lumbar vertebra. Its rami, both in number and direction, were extremely varied. It was invariably the largest of the lumbar ganglia, and when palpating for the sympathetic chain, the most easily identified.

As a matter of practical operative importance, it is suggested that usually the body of the fourth lumbar vertebra can be identified by the overlying aorta bifurcating into the common iliacs. In a similar manner, the first lumbar vertebra can be identified by the medial lumbocostal arch. If a ganglion is present on the body of the first lumbar vertebra, it is usually not seen, since it is covered by this structure. Exposure of it is unnecessary, since its removal is not indicated. For adequate denervation, sympathetic tissue should be removed between these two points. Sympathetic tissue overlying the fourth lumbar vertebra is usually obscured by the common iliacs. Its removal is often hazardous, and under such conditions, not advisable.

SUMMARY

- 1 The inter-relationship of the sympathetic nervous system and peripheral vascular disease is reviewed.
- 2 The end results in a series of 150 patients with lumbar sympathectomy are analyzed.
- 3 Probable factors contributing to many of the disappointing results are discussed.
- 4 Proper selection of patients for this procedure, anatomic variations and adequacy of sympathetic denervation are emphasized.

CONCLUSION

- 1 Lumbar sympathectomy adequately executed, in properly selected cases of organic peripheral vascular disease, is an adjunctive procedure of merit.

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CORRECTIONS

In the January, 1948, issue of the ANNALS OF SURGERY, the last paragraph of Dr J William Hinton's article "One-stage Resection and Anastomosis of the Colon" on page 12 should read "Proponents of multiple-stage colonic surgery state that the low mortality possible with this operation outweighs its disadvantages, Rankin^{26, 27} and Lahey¹⁷ Cheever⁵ in 1931, reported comparable series of these cases and showed that in their hands, onestage resection, with anastomosis and a proximal vent for *decompression* had a lower mortality than the exteriorization procedures "

* * *

In the March, 1948, issue of the ANNALS OF SURGERY, the sentence beginning on line 36 of Dr Hayes Martin's article "Juvenile Nasopharyngeal Angiofibroma" on page 534 should read "We suspect that Shaheen's cases of 'malignant transformation' were actually malignant nasopharyngeal *cancer* and not nasopharyngeal fibromas in the beginning "

THE EFFECTS OF PRISCOL (2-BENZYL-4, 5-IMIDAZOLINE HCl) ON PERIPHERAL VASCULAR DISEASES, HYPERTENSION AND CIRCULATION IN PATIENTS*†‡

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ADRENOLYTIC AND SYMPATHOLYTIC DRUGS have been known and investigated for many years. By blocking action of adrenalin or blocking effector sympathetic pathways these drugs might aid study, diagnosis, or treatment of paraganglioma, pheochromocytoma, peripheral vascular diseases or hypertension. Currently, three drugs are receiving clinical trial. Etamon (tetraethylammonium chloride or bromide) is essentially a ganglionic blocking agent but is not adrenolytic (Acheson and Moe¹). By blocking ganglia other than those of the sympathetic nervous system, it may produce abnormal function of the eye, bladder, and gastro-intestinal tract. Dibenamine (dibenzyl beta-chlorethyl amine hydrochloride), Nickerson and Goodman,² and Priscol (2-benzyl-4, 5-imidazoline HCl) more specifically block sympathetic motor pathways acting apparently at their termination in smooth muscle. These drugs are adrenolytic. Dibenamine has a more prolonged action than Priscol but must be administered intravenously. Effects of Priscol last three to eight hours and the drug may be given orally, intramuscularly, or intravenously.

Hartman and Isler³ first reported Priscol in 1939, stating that of a group of phenyl-substituted alkyl imidazolines examined, it produced greatest depression of blood pressure. The same year Meier and Mueller⁴ reported that Priscol dilates vessels of mucosa and skin but that vasodilatation is more pronounced in extremities. Also, they demonstrated that Priscol and adrenalin together produced lowering of blood pressure. Meyer⁵ later clarified and proved adrenolytic properties of Priscol. Chess and Yonkman⁶ demonstrated that although Priscol was adrenolytic as judged by reduction of blood pressure, it was not adrenolytic or sympatholytic with respect to all cervical sympathetic functions studied. Yonkman et al⁷ also demonstrated stimulation of ileum of dogs, a cholinergic response blocked by atropine. Ahlquist and Woodbury⁸ observed that Priscol inhibits pressor and constrictor effects of several sympathomimetic drugs but has little action on their depressor or dilator effects. Ahlquist, Huggins, and Woodbury⁹ subsequently report that Priscol acts primarily as a sympathomimetic agent producing peripheral vasodilatation, cardiac stimulation, coronary vasodilatation, increased cardiac out-

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‡ Supplies of Priscol and a grant in aid given by Ciba Pharmaceutical Products Incorporated, Summit, New Jersey

put and some inhibition of the gastro-intestinal musculature. They describe occasional elevations of blood pressure and believe that changes of pressure depend upon a balance between peripheral vasodilatation and increased cardiac output. In animals they describe histamine-like properties and also acetylcholine-like effects. They conclude that Priscol is an effective sympathomimetic anti-pressor and adienolytic agent. Further experimental studies will not be reviewed except to state that Hatt¹⁰ using the Stirling heart-lung preparation found that damaging doses of Priscol were one hundred times greater than those used to reduce blood pressure. Our own experiments¹¹⁻¹⁴ confirm adienolytic and sympatholytic properties in dogs and man. Current experiments also show that neurogenic hypertension in dogs is occasionally reduced but rarely brought to normal even by large doses. Pituitin will increase blood pressure after reduction with Priscol.

There are many reports of clinical use of Priscol in the European and South American literature. Only a few will be quoted. Zothe¹⁵ demonstrated decrease of circulation time to the toe. Siedek¹⁶ calculated cardiac output in 14 patients and usually found moderate increase. Lipross¹⁷ reported increase of finger and toe temperatures in patients after Priscol¹⁸ and abolition of skin temperature gradient of arms and legs. De Gennaro and Bertazzi¹⁹ demonstrated increase of gastric motility and hastening of gastric evacuation. Luft²⁰ compared effects of several drugs upon skin temperature of healthy individuals, with effects in two patients with thromboangitis obliterans and one with arteriosclerosis. He found that Priscol caused greatest increase of temperature. Other observers have reported using Priscol for frostbite, Shioder,²¹ Raynaud's disease, Kohlmayer,²² diabetic arteriosclerosis, Schietz,²³ and hypertension, Singer.²⁴ More than 40 additional authors have reported varying degrees of success using Priscol for a wide variety of circulatory disorders. Frequently relief from pain associated with vascular disease has been described.

This report deals with results of clinical investigation during the last two years. No patient has been treated longer than nine months, but many are continuing treatment.^{25, 26} Material will be presented in three sections: (1) clinical observations during testing or treatment of peripheral vascular disease, (2) testing or treatment of hypertension, and (3) general effects of Priscol on circulation.

Experimental and early clinical evidence indicated advisability of using larger dosage schedules than previously reported. Except for time of onset and maximum response little difference in total effect has been observed between administration by oral, intramuscular, or intravenous routes. Amounts of Priscol administered to some patients with peripheral vascular disease described in section 2 now seem excessive and amounts administered in hypertension, section 3, may be too low. To facilitate interpretation schedules now believed approximately correct will be presented. Twenty-five to 75 mg intravenously or intramuscularly apparently adequately tests patients with peripheral vascular disease and 25 to 50 mg orally every three or four hours.

apparently maintains maximum therapeutic effects. Tests for patients with hypertension have been based upon intravenous injection of 50 mg followed an hour later by another 50 mg and usually followed after another hour by injection of 100 mg. Dose schedule for treatment of hypertension varies but is usually gradually increased to a maximum of 75 mg every two hours. Since lowering of blood pressure has not constantly followed test or treatment, effective dose range or potential value for treatment of hypertension has not been established.

Complications or side effects will be presented in advance of clinical reports. Twenty-five to 75 mg as an initial dose produces a sensation of crawling in the skin, a feeling of warmth of face and ears, a sensation as if hair were rising, a chilly sensation with development of "goose flesh," and occasionally apprehension. Patients may also describe increase of heart rate. Occasionally nausea occurs and, rarely, vomiting. Continued treatment, using 25 to 75 mg every two to four hours is usually associated with fewer or milder symptoms. Test doses as high as 200 mg per patient, accentuate the above symptoms and also produce disability from postural hypotension. Occasionally such doses cause audible peristalsis, dizziness or a far-away feeling, sweating, congestion of the nose, or headache.

EFFECT OF PRISCOL IN PERIPHERAL VASCULAR DISEASE AND RELATED CIRCULATORY DISORDERS

Forty-three patients with vascular disease or related disorders of extremities received Priscol. Six had Raynaud's disease, 15, arteriosclerotic obstructive vascular disease, six, thromboangitis obliterans, three, popliteal aneurysms, seven, extremity pain loosely grouped as causalgia, four, phlebitis, and two, acute ischemia. Observations varied from simple testing of the effects of single doses to study of results of prolonged treatment.

Results of administration of similar doses of Priscol orally, intramuscularly, or intravenously were compared in ten of these patients with peripheral vascular disease. Intravenous injection produced generalized vasodilatation within two minutes. Intramuscular administration produced vasodilatation within ten minutes and oral within half an hour. Although delayed flushing after oral administration was less intense than that produced by intravenous or intramuscular administration, its lasting or total effect was usually equivalent.

1 *Raynaud's disease*. Six patients gave histories and presented clinical criteria compatible with diagnosis of Raynaud's disease. Phasic color changes of digits of hands and feet occurred spontaneously and were produced by exposure to cold or by emotional stress. Blanching, rubor, and cyanosis occurred in each patient, often simultaneously in separate areas of fingers or toes. Rubor or cyanosis was produced by placing hand or foot in ice water and blanching by exposing the patient to refrigerator temperatures. Not included are any patients complaining solely of reddening or pallor of the hands on exposure.

Two patients had undergone sympathectomy of the upper extremities

One had symptoms seven years. Two years after onset of symptoms, a preganglionic sympathectomy was performed on the left and a ganglionectomy on the right. Some scleroderma had developed before sympathectomy and ulcers had appeared. Improvement of either hand lasted less than a year and trophic changes were progressing. Because of persistent pain and ulceration this patient was tested and treated with Priscol. Two hundred milligrams intramuscularly increased temperature of the fingers and toes four degrees centigrade. The patient could not tolerate immersion of the hands in ice water before Priscol. Afterward he kept his hands submerged five minutes without pain or blanching. Pain was relieved for eight hours. He was sent home taking 25 mg. every four hours. During seven months symptoms have been relieved, although not completely, and treatment is continuing.

The second patient had bilateral upper dorsal ganglionectomy one year after onset of symptoms. A year after operation discoloration and pain recurred. When treated, trophic changes of skin or ulcer had not developed. Three intramuscular injections of 75 mg. of Priscol were given at half hour intervals. The first dose effected warming of hands and relief of pain. Second and third injections effected no further change. Oral administration of 25 mg. at six hour intervals in the hospital and at home maintained improvement. After five weeks the patient reported that his hands were better in color and more comfortable but that the drug made him nervous.

A third patient had treatment by Priscol before and after sympathectomy. Symptoms had been present two years. All four extremities were involved but the feet troubled most. Periods of ischemia and pain lasting several days recurred. When first seen an episode had persisted two weeks and produced sharp burning pain and paresthesia of the right foot. This foot was cold and pale but developed rubor when dependent. Dorsal pedis and posterior tibial arteries were fully palpable and oscillometric pulsations in the mid-calf were normal. There was an area of anesthesia about the toe. The left leg and both hands evidence phasic color changes characteristic of Raynaud's disease. On admission the temperature of the right toe was 22.4° C. and of the left, 28.8° C. After hospitalization for two hours without treatment temperatures were respectively 23 and 32. Temperature of skin near the umbilicus varied between 36.3 and 37. Forty milligrams of Priscol were given intramuscularly. Twenty-five minutes later temperature of the right toe was 30.3 and of the left, 36. Fifteen minutes later temperatures were respectively 34.1 and 36. Three hours after Priscol temperatures were right toe, 36.5, left, 36.4, and umbilicus, 37. Twenty-five to 50 mg. were then given intramuscularly every two hours for five days. Toe temperatures were maintained always over 33. Finger temperatures were similarly increased and maintained. Placing of hands or feet in ice water was well tolerated. Treatment was omitted for one day and relapse occurred. Since chronic treatment by Priscol was not being employed when this patient was tested, bilateral lumbar sympathetic ganglionectomies were performed and three months later bilateral upper dorsal

sympathetic ganglionectomies. Increase of temperature of digits similar to that effected by Priscol followed operation. During the next nine months symptoms were relieved but as cold weather returned moderately severe phasic color changes reappeared. Priscol, 50 mg four times a day, was then given orally at home with definite benefit.

Because of these encouraging results the next three patients encountered were treated by Priscol and have not since required sympathectomy. Their clinical course, tests and treatment were similar and will be described together. All were women. Duration of symptoms was respectively eighteen months, thirty months, and two years. One patient had undergone a right upper dorsal ganglionectomy followed by recurrence. After a year symptoms were again equal in the two hands even though the right remained warmer. In all three patients symptoms were progressive but advanced trophic changes of skin or ulceration had not developed. Fifty mg of Priscol orally, intravenously, or intramuscularly increased temperature of the digits in each limb of each patient with the exception of one right arm previously sympathectomized. The increase was to within three degrees of abdominal skin temperature in the extremities of two patients and within one degree in the third. The temperature of the sympathectomized limb, however, did not increase. Before Priscol patients would hold their hands in ice water 36 to 89 seconds with severe pain. This was followed by intense rubor and cyanosis and rarely areas of ischemia. Within 15 to 30 minutes after administration of Priscol these patients held their hands in ice water three to five minutes comfortably and stated they could continue indefinitely. Following removal of the hands from ice water after Priscol some redness developed but little, if any, cyanosis and no ischemia. The single oral dose required to effect this protection was 25 mg in one patient, 50 in another, and 75 mg in the third. Exposure of two patients in a large refrigerator at temperatures of 40° C induced phasic color changes, predominantly pallor, before Priscol. After the drug, exposure for fifteen minutes produced no change. Protection against pain and discoloration of the one sympathectomized arm equaled that of the opposite arm.

These three patients have been taking Priscol at home six to nine months. Dose schedules have been varied to determine amount necessary to afford protection from attacks. Each patient has required a minimum of 50 mg morning, before lunch, mid-afternoon, and evening in cool weather, decreasing dosage on warm days and only occasionally increasing it above this amount. Although slight discoloration of fingers occurs once in a while, particularly before the morning dose, the patients are enthusiastic about results. There has as yet been no evidence of development of toxicity or tolerance and side effects have been considered of minor importance.

2 *Arteriosclerotic obstructive disease of legs*. Fifteen patients varying in age from 47 to 77 had gradually progressive symptoms of incompetent arterial circulation through the legs and feet and clinical criteria warranting a diagnosis of arteriosclerosis. Results will be described in three groups: patients tested

and treated by Priscol, tested and treated by sympathectomy, or tested only

Five patients were tested and then treated by Priscol. Two men, aged 71 and 77, had ulcers about both ankles and feet. They also had angina on exertion. Fifty milligram test doses produced moderate increase of temperature of the feet, and during treatment in the hospital and at home ulcers healed. Since conservative and other medical treatments were also employed, evaluation is difficult but Priscol seemed to assist management.

A third patient, male, age 55, had had one leg amputated. Circulation in the remaining leg was minimum and resting pain had developed. Fifty milligrams of Priscol intramuscularly increased great toe temperature 2 degrees. After an hour another 50 mg increased it an additional 2 degrees, or to within three degrees of temperature of the skin near the umbilicus. Treatment at home using Priscol and no other medication effected moderate relief of symptoms.

A fourth patient, male, age 55, gave a history of exertional and substernal discomfort and mild episodes of nocturnal dyspnea, during five years. Intermittent claudication developed during the last eleven months. Fifty milligrams intravenously warmed both feet and markedly improved circulation as judged by postural tests. Fifty milligrams were then prescribed for use at home orally four times a day. Although Priscol made this patient nervous, he now states that the feet no longer ache and no longer are fatigued or cramped within two blocks. He can now walk seven or eight blocks before claudication. On two occasions after evening drinking, he has been awakened at night by transient shortness of breath and cough. This patient also states that mental faculties are much clearer when taking the drug.

The fifth patient was a 73-year-old woman, who gave a history suggesting a myocardial infarction seventeen years ago. She since has had recurring attacks of angina. Electrocardiograms were consistent with coronary insufficiency. Slightest exertion produced substernal pain. One year before admission an ulcer of the left big toe developed. It was treated conservatively without healing. During the month before admission pain of the left toe and foot steadily increased. The patient was then hospitalized and treated by intermittent venous occlusion and papaverine hydrochloride for four days with no relief from pain. During the next four days two lumbar sympathetic blocks were employed, each effecting partial relief from pain. In spite of the bad cardiac status, Priscol was tested. Fifty milligrams given intramuscularly and repeated after 45 minutes effected moderate relief of pain but there was no increase of temperature of the involved toe. Two days later lumbar paravertebral block was repeated with a similar result. During the next two weeks 50 mg of Priscol were given intramuscularly or by mouth every two hours. Intermittent venous occlusion was continued. Pain gradually ceased with the ulcer slowly decreasing in size. The patient was then discharged with instructions to take 25 or 50 mg at home every three hours when awake. Acute substernal pain, which had been occurring every few weeks before

treatment, recurred once one month later. Two months after leaving the hospital a fatal myocardial infarction occurred. Comfort in the foot had persisted and at the time of death the ulcer had healed.

Five additional patients with arteriosclerotic vascular obstructive disease were tested using Priscol but not treated by the drug. Three developed increase of temperature of all extremities except the most seriously involved. Because of severe pain, or local gangrene, amputation was advised in each. The fourth had less advanced arterial obstruction. One hundred milligrams of Priscol increased temperature of the left toe 1.7 degrees, and temperature of the right toe, 0.2 degrees. Sympathectomy was advised on the left, to be followed by sympathectomy on the right. The fifth patient, age 41, was tested on two occasions. His right great toe had been amputated a year previously and the wound had healed. When first seen the right little toe was gangrenous. Fifty milligrams of Priscol orally increased temperature of the left great toe until it equaled that at the umbilicus but increased warmth of the right middle toe only to a temperature 3.2 degrees below that of abdominal skin. A right lumbar sympathectomy was then performed, and the remaining toes were amputated. Pain was not relieved and gangrene developed about the amputation site. Twenty-one days after operation pain had increased and the patient was obviously deteriorating. Priscol was again employed as a test. Temperature of the gangrenous foot did not increase after 50 mg orally. Two and one-half hours later 75 mg orally again did not increase temperature or relieve pain. An hour later necrotic tissue about the wound was dissected free and removed. Following this the patient screamed with pain even though morphine was given. During the next six hours pre-cordial pain developed and radiated to the left arm. Electrocardiogram the next day revealed abnormal tracings consistent with a posterior infarct. Nine days later the right leg was amputated. Two and six days after amputation electrocardiograms revealed left axis deviation only. Ten days after amputation a cerebral vascular accident occurred with right hemiplegia. Death occurred eight days later. At no time was this patient treated chronically with Priscol.

The remaining five patients of the arteriosclerotic group had tests before or after lumbar sympathetic ganglionectomy. Three were tested before and a week or more after operation. Fifty to 75 mg of Priscol warmed the most involved foot and toe of two of the patients to a temperature equivalent to that effected by sympathectomy. A week after operation 50 to 75 mg warmed the other extremities of each patient but did not increase temperature of the sympathectomized limb. The least involved normally innervated limb of the third patient behaved differently. Preoperatively 50 mg intramuscularly increased temperature of both feet to that at the umbilicus. The day after left lumbar ganglionectomy the temperature of the left foot equaled that at the umbilicus but the right toe temperature was 4 degrees colder than before operation. Temperature of this cool right foot increased only one degree after 100 mg of Priscol intravenously. Temperature of the sympathectomized leg did not

increase. Two days later the right foot was warmer and responded to 50 mg of Priscol intravenously by equaling abdominal temperature. Repetition of the same test five days later again similarly increased temperature of the right foot without increasing that of the sympathectomized limb.

Two patients were tested at longer intervals after sympathectomy. One was examined five years after left leg amputation and right lumbar sympathetic ganglionectomy. The temperature of the right foot and toe equaled abdominal skin temperature and did not increase after 50 mg of Priscol intramuscularly. The other patient was tested eight months after right lumbar ganglionectomy and four months after left lumbar ganglionectomy. Foot and toe temperatures on both sides equaled or slightly exceeded umbilicus temperature. Fifty milligrams of Priscol intramuscularly did not further increase temperature of foot and toe.

3 *Thromboangitis obliterans (Buerger's disease)* History and clinical observations led to a probable diagnosis of thromboangitis obliterans in six patients. As nearly as could be determined each had discontinued smoking. The first, a 33-year-old veteran, had involvement of hands and feet during six years and had had episodes of migratory phlebitis. He had been hospitalized elsewhere repeatedly, receiving various treatments including lumbar sympathetic blocks. Sympathectomy had been refused. Priscol, 50 mg warmed the digits of the extremities less than 2 degrees. Fifty to 75 mg was then given every three or four hours intramuscularly or orally during three weeks in the hospital. Symptomatic relief was described and an ulcer on the right middle finger healed. A small area of phlebitis developed in the right leg and healed. Treatment was continued orally at home ten days and then discontinued for two weeks. During the holiday another finger developed an ulcer, and the patient stated that his hands were stiffer and more painful. For seven months he has taken 50 mg of Priscol orally every three hours while awake and has reported satisfaction with treatment.

The next two patients were likewise treated in the hospital before home treatment by Priscol was instituted. One, age 46, had involvement of all four extremities with pain and discoloration of the tip of the right index finger. He was treated in the hospital for nine days, using Priscol and conservative treatment. Relief of pain occurred and the discolored finger improved with demarcation of a small patch of dry gangrene. The other patient, age 58, had had symptoms of thromboangitis obliterans for fifteen years. His left leg had been amputated and diagnosis had been confirmed by pathological examination. An ulcer of the index finger of the right hand developed and caused pain. An excessively large dose of Priscol, 175 mg, was given intramuscularly. This effected relief of pain and increase in temperature of right thumb and toe. It also produced reduction of blood pressure from 140/95 to 68/60, a chilly sensation and vomiting and diarrhea.

The remaining three patients with thromboangitis obliterans had sympathectomies before or after Priscol. One gave a history of involvement of

TABLE I—Range of Blood Pressure Before 6 Gm of Sodium Amytal and During Night, Before Priscol and During First Hour Afterward, and After Second Stage of Paravertebral Sympathectomy*

Patient	Age	Sodium Amytal Test Before Test	During Night	Priscol 'Acute Test' Before Drug	After Drug	One to two weeks After Sympathectomy
A Good reduction after sympathectomy						
ML	43	250/150→210/130	205/140→154/100	251/170→232/140	189/110→121/70	170/100→100/70
EE	31	200/124 160/110	140/100 130/90	182/122 168/118	148/92 121/71	152/96 101/70
MH	26	290/170 230/150	200/150 160/122	234/162 220/151	210/160 178/132	165/130 140/88
NL	43	240/118 170/98	172/110 130/70	171/92 161/91	186/91 162/86	140/100 100/66
B Moderate reduction after sympathectomy						
IS	44	230/140→180/120	178/132→150/100	208/144→190/132	160/102→116/66	161/101→130/70
RR	31	230/130 170/100	180/120 150/100	182/128 160/120	141/96 121/72	170/147 110/88
HF	37	220/170 180/124	190/110 170/120	202/118 182/114	210/132 142/96	180/120 110/82
FP	45	232/130 180/100	180/110 170/96	236/134 212/118	142/112 108/80	198/100 140/70
C Insignificant reduction after sympathectomy						
SO	45	210/130→186/106	180/100→150/90	220/136→188/130	110/70 → 96/50	210/132→170/100
MC	44	240/130 200/122	220/140 190/100	230/126 210/188	280/160 240/124	240/130 180/90

* All readings obtained with patient resting in supine position

Interpretation is difficult but it would appear that reduction after Priscol agrees with that after sympathectomy in patients ML and RR, amytral in FP and SO, both in EE, IS and MC and neither in MH, NL, and HF

toes and fingers, beginning ten years ago at the age of 25. Five years before receiving Priscol a bilateral lumbar sympathectomy had been performed and two years ago a bilateral upper dorsal sympathectomy. During the month before treatment an ulcer had developed on the tip of the left middle finger and the entire distal phalanx had discolored. Eight days of treatment using 50 mg. every four hours produced moderate relief from pain. Amputation of the distal phalanx was then performed and the wound healed. Since discharge from the hospital this patient has taken four to six, 50 mg. doses of Priscol each day for five months with the exception of occasional intervals of a week or two without drug for control observation. He states that while taking Priscol the hands and feet feel better, with less stiffness and no pain. His hands and feet feel colder and stiffer and are "tired and more easily fatigued" during periods without treatment. Another patient, age 42, was tested two years and seven months after left lumbar sympathetic ganglionectomy and just preceding right ganglionectomy. One hundred milligrams of Priscol intramuscularly effected moderate increase of temperature of the toes of the non-sympathectomized limb but did not increase temperature of the sympathectomized leg. Increase of temperature of the right toes after the right lumbar sympathectomy was moderate, equaling that effected by Priscol. The last patient, age 32, received 200 mg. intravenously with little increase of temperature of the involved foot. There was also little increase of temperature after sympathectomy.

4. *Popliteal aneurysm* Three patients with popliteal aneurysm were tested. One had a left popliteal aneurysm at the age of 19. It had been noticed as a small lump for three years and had ruptured six days before admission, producing pain and swelling. Left lumbar sympathectomy and ligation and excision of the defective area of the popliteal artery were performed. The day after operation 50 mg. of Priscol were given intramuscularly. This effected increase of temperature of the right foot and toe, equaling the temperature of the sympathectomized side but did not increase temperature of this operated side. Fourteen days later 50 mg. were given twice intramuscularly, an hour apart, again with warming of the right foot to equal the temperature of the skin near the umbilicus and without increase of temperature of the left leg. The remaining two patients, aged 70 and 77, had popliteal aneurysms associated with thrombosis. Each was treated by Priscol with little effect and both developed gangrene and had amputation.

5. *Causalgia-type of pain and circulatory disorder* Seven patients with limb pain have been grouped together under the heading *causalgia*, using the term as it is conventionally broadly defined. Each has been treated by Priscol. No patient had peripheral nerve injury with neuroma and pain required for a diagnosis of causalgia according to the limited definition of the term.

The first patient had burning of both feet associated with increased warmth and blood flow, persisting seven months. Pain began after fracture of several foot bones during a fall. Tenderness and pain prevented walking. Sympathetic

blocks were compared with intramuscular injection of 100 mg of Priscol. Subjective relief of pain was described as lasting 15 to 20 minutes after both procedures. Similar relief was also described after placebo tablets or injections of saline into the lumbar muscles. Treatment since has been psychiatric.

The second patient, five weeks before testing, had had a right great toenail removed for "ingrowing toenail" and had subsequently developed intense pain in the right foot, with increased warmth, dependent rubor, and evidence of increased blood flow. Fifty milligrams of Priscol intramuscularly partially relieved pain and another 50 mg an hour later completely relieved pain for seven hours. The test was repeated two days later, again with relief, this time persisting six weeks. She returned two weeks after recurrence. Circulation at this time was essentially normal as judged by postural tests. Priscol taken at home for two weeks again relieved pain.

A third patient developed pain in the left great toe after wearing a tight shoe three months before treatment. All arteries were fully palpable but there was dependent rubor of the left foot. Two intramuscular injections of 65 mg of Priscol increased the temperature of both feet and relieved pain. Priscol was continued at home for one month. All symptoms were relieved, and when the patient returned after a two-week holiday, there had been no recurrence. Postural tests of circulation were normal.

The three remaining patients in this group had upper arm pain associated with some injury of the brachial plexus or the cervical nerve roots. One had an avulsion injury followed by paralysis of the left arm one year before treatment. Motor function had partially returned. When first examined the arm and hand were cold. Atrophy and persistent pain had developed. Upper dorsal sympathetic blocks relieved pain temporarily and a sympathectomy was performed. Warmth and motor function of the hand increased and muscular development improved but pain recurred within two months. One year after sympathectomy he was hospitalized one week and treated by progressively increasing doses of Priscol. The maximum was 75 mg every two hours. Pain was relieved but recurred within three weeks. Three months later he was sent Priscol for use at home and took 50 mg every four hours. Again he reported relief but during continued treatment pain returned. He finally stated that the medicine did not help and discontinued treatment.

A second patient injured his right shoulder two months before admission and gradually developed pain in the right middle and index fingers with ulceration of the index finger. A sympathetic block partially relieved pain for thirty minutes. Fifty milligrams of Priscol orally also temporarily relieved pain. Increase of finger temperature equaled that produced by the block.

The third patient complained of pain in the ring finger and palm of the right hand. This had been present for seven weeks and began after the patient had awakened one night with intense pain between the shoulders. A diagnosis of rupture of the cervical disc between C-7 and T-1 was established and the neurosurgeons removed the protruding portion of the disc. Pain recurred

three weeks later. Three upper dorsal lumbar sympathetic blocks each relieved this pain. One hundred ten milligrams of Priscol intramuscularly and 100 mg orally similarly relieved pain for an hour and a half. Sympathectomy was subsequently performed but pain again recurred.

The last patient in this group had both legs amputated because of arteriosclerotic vascular obstructive disease with gangrene and intense pain. Pain had persisted one year following the last amputation. Twenty-five milligrams of Priscol were given orally every two hours for two days. This did not relieve pain but did produce nausea and apprehension.

6 *Miscellaneous Vascular and Pain Problems*

A VENOUS THROMBOSIS OR PHLEBITIS Three patients with intravascular clotting in deep veins of the leg were tested but not treated by Priscol. Two had had pulmonary emboli, and one had recurring phlebitis with edema. In each patient Priscol warmed the involved leg and foot and relieved discomfort.

A fourth patient had had recurring episodes of left lower leg superficial thrombophlebitis. After removing the saphenous veins and tributaries by stripping and evulsion, episodes of lower leg cellulitis occurred on both sides and edema developed. After the last episode 50 mg of Priscol intramuscularly brought toe temperatures up to temperature at the umbilicus. A left lumbar sympathectomy was then performed and subcutaneous tissue and veins of the areas of recurrence in both lower legs were radically excised. Two days after operation and again eight days later Priscol brought the temperature of the right foot up to that of the left and equal to that at the umbilicus.

B ISCHEMIA Three patients with acute obstruction of blood flow to a limb were tested and treated with Priscol. The first, a 24-year-old athlete, fractured the right tibia. After reduction the right leg and foot were placed in a cast. Two days later pallor of the toes was observed and it was found that motor function and sensation were diminished. The cast was removed. Two hours later the foot remained colorless and neither dorsal pedis or posterior tibial arteries could be palpated. Fifty milligrams of Priscol intravenously effected restoration of a pink color and return of warmth within five minutes. Fifty milligrams were then given intramuscularly every four hours. Twenty-four hours later the dorsal pedis and posterior tibial arteries were fully palpable.

A second patient developed a colorless lower leg after fracture and dislocation of the right knee. Emergency surgery was performed elsewhere. The popliteal artery was thickened and contained a thrombus. The thrombus was removed but blood did not flow through the injured artery. Three days later the foot was discolored. Priscol was then tried without improvement. The third patient, a 65-year-old hypertensive patient with coronary disease, developed an embolus presumably located in the right popliteal artery. Fifty mill-

blocks were compared with intramuscular injection of 100 mg of Priscol. Subjective relief of pain was described as lasting 15 to 20 minutes after both procedures. Similar relief was also described after placebo tablets or injections of saline into the lumbar muscles. Treatment since has been psychiatric.

The second patient, five weeks before testing, had had a right great toenail removed for "ingrowing toenail" and had subsequently developed intense pain in the right foot, with increased warmth, dependent rubor, and evidence of increased blood flow. Fifty milligrams of Priscol intramuscularly partially relieved pain and another 50 mg an hour later completely relieved pain for seven hours. The test was repeated two days later, again with relief, this time persisting six weeks. She returned two weeks after recurrence. Circulation at this time was essentially normal as judged by postural tests. Priscol taken at home for two weeks again relieved pain.

A third patient developed pain in the left great toe after wearing a tight shoe three months before treatment. All arteries were fully palpable but there was dependent rubor of the left foot. Two intramuscular injections of 65 mg of Priscol increased the temperature of both feet and relieved pain. Priscol was continued at home for one month. All symptoms were relieved, and when the patient returned after a two-week holiday, there had been no recurrence. Postural tests of circulation were normal.

The three remaining patients in this group had upper arm pain associated with some injury of the brachial plexus or the cervical nerve roots. One had an avulsion injury followed by paralysis of the left arm one year before treatment. Motor function had partially returned. When first examined the arm and hand were cold. Atrophy and persistent pain had developed. Upper dorsal sympathetic blocks relieved pain temporarily and a sympathectomy was performed. Warmth and motor function of the hand increased and muscular development improved but pain recurred within two months. One year after sympathectomy he was hospitalized one week and treated by progressively increasing doses of Priscol. The maximum was 75 mg every two hours. Pain was relieved but recurred within three weeks. Three months later he was sent Priscol for use at home and took 50 mg every four hours. Again he reported relief but during continued treatment pain returned. He finally stated that the medicine did not help and discontinued treatment.

A second patient injured his right shoulder two months before admission and gradually developed pain in the right middle and index fingers with ulceration of the index finger. A sympathetic block partially relieved pain for thirty minutes. Fifty milligrams of Priscol orally also temporarily relieved pain. Increase of finger temperature equaled that produced by the block.

The third patient complained of pain in the ring finger and palm of the right hand. This had been present for seven weeks and began after the patient had awakened one night with intense pain between the shoulders. A diagnosis of rupture of the cervical disc between C-7 and T-1 was established and the neurosurgeons removed the protruding portion of the disc. Pain recurred.

three weeks later. Three upper dorsal lumbar sympathetic blocks each relieved this pain. One hundred ten milligrams of Priscol intramuscularly and 100 mg. orally similarly relieved pain for an hour and a half. Sympathectomy was subsequently performed but pain again recurred.

The last patient in this group had both legs amputated because of arteriosclerotic vascular obstructive disease with gangrene and intense pain. Pain had persisted one year following the last amputation. Twenty-five milligrams of Priscol were given orally every two hours for two days. This did not relieve pain but did produce nausea and apprehension.

6 *Miscellaneous Vascular and Pain Problems*

A VENOUS THROMBOSIS OR PHLEBITIS Three patients with intravascular clotting in deep veins of the leg were tested but not treated by Priscol. Two had had pulmonary emboli, and one had recurring phlebitis with edema. In each patient Priscol warmed the involved leg and foot and relieved discomfort.

A fourth patient had had recurring episodes of left lower leg superficial thrombophlebitis. After removing the saphenous veins and tributaries by stripping and evulsion, episodes of lower leg cellulitis occurred on both sides and edema developed. After the last episode 50 mg of Priscol intramuscularly brought toe temperatures up to temperature at the umbilicus. A left lumbar sympathectomy was then performed and subcutaneous tissue and veins of the areas of recurrence in both lower legs were radically excised. Two days after operation and again eight days later Priscol brought the temperature of the right foot up to that of the left and equal to that at the umbilicus.

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grams of Priscol were given every four hours for three days, and the patient was heparinized. The foot remained viable, but after recovery the patient complained of claudication and fatigue on exercise.

C PAIN As a control for relief of pain described in the above reports six patients with pain or other varieties were tested with Priscol. Four had abdominal pain, one from intussusception, one from common duct obstruction, and two from peptic ulcer. Each was given 50 mg of Priscol intramuscularly or intravenously without relief from pain. The fifth patient had a painful stasis dermatitis of the left leg. Twenty-five milligrams orally produced warming of the legs but no relief of pain. Another patient with arthritis in the hands was tested both by sympathetic block and by 50 mg of Priscol intravenously without relief of pain.

THE EFFECT OF PRISCOL ON BLOOD PRESSURE OF PATIENTS WITH HYPERTENSION

Thirty-nine hypertensive patients have been treated or tested with Priscol. In general each had advanced essential hypertension or hypertensive cardiovascular renal disease. Only one had definite coronary disease demonstrated by electrocardiogram. Many had hypertensive retinitis and a few papilledema. The oldest patient was 53. Treatment in the hospital consisted of 25 to 75 mg of Priscol usually by hypodermic administration every two to four hours. Treatment at home employed 25 to 75 mg orally every three or four hours. Many patients had tests using Priscol. These were performed by injecting 50 mg intravenously, followed one hour later by another 50 mg and then with three exceptions completing the test at the third hour by injection of 100 mg. Blood pressure during the hour after the last injection will be described and transient changes omitted. Occasionally sympathectomy was performed after a week or more of treatment or after a Priscol test. All blood pressures reported below were taken with the patient resting in a supine position. Six types of observations will be presented separately.

1 *Hypertension treated by Priscol during a week or more of hospitalization and then by sympathectomy* (Five patients) The first patient had tachycardia and fluctuating blood pressure and was suspected of having an adrenal tumor. After receiving Priscol in the hospital for nine days pressure decreased from around 190/110 to around 134/96. Treatment was continued one month at home. Fluctuations of pressure with frequent high readings recurred and tachycardia persisted. A splanchnicectomy of the posterior Smithwick-type was then performed. Both adrenal glands were explored and neither contained a tumor. The complaint of tachycardia persists but blood pressure remains reduced.

The remaining four patients failed to have significant lowering of pressure during 5- to 10-day periods of treatment even though dosage was increased to 75 mg every two hours. Each was then treated by total thoracic and partial

to total lumbar paravertebral sympathectomy, splanchnicectomy, and caliac ganglionectomy²⁷. Blood pressure following operation was reduced toward normal in two and only moderately lowered in two.

2 *Hypertension tested by Priscol and subsequently treated by sympathectomy* (Eleven patients) One patient had no significant lowering of pressure after 200 mg of Priscol and also no reduction during the second week after splanchnicectomy. Ten patients had Priscol tests, standard sodium amytal tests, and then subtotal to total paravertebral sympathectomy. Results are presented in Table I.

3 *Priscol tests in patients with hypertension persisting after sympathectomy* Tests were performed in six patients with hypertension persisting 8 to 36 months after treatment by sympathectomy. One had had a splanchnicectomy. Blood pressure which ranged around 176/114 did not change after 200 mg. Another after splanchnicectomy had a pressure around 230/120. It reduced to 122/68 after 200 mg of Priscol. The remaining four patients had subtotal to total paravertebral sympathectomies. In three Priscol did not produce significant reduction of pressure. In the fourth the test lowered the reading from around 204/122 to 140/94. This patient was then treated at home and had moderate lowering of pressure.

4 *Hospital treatment of patients with hypertension persisting after sympathectomy* Four additional patients with hypertension persisting 6 to 26 months after sympathectomy were treated five days or longer in the hospital without using the Priscol test. Three had thoracolumbar splanchnicectomy. Treatment did not produce significant change of blood pressure. The fourth patient had paravertebral sympathectomy. She was treated in the hospital with slight reduction and subsequently at home for two months without significant reduction of pressure.

5 *Hypertension tested and treated by Priscol* Six patients had 200 mg tests and then treatment by Priscol. The tests effected reduction of pressure to normal in three and little, if any, reduction in three. During treatment in the hospital for a week or more, a moderate and probably insignificant reduction of pressure occurred. Each was then sent home instructed to take the drug three weeks, discontinue it two weeks, and then, if desired, resume treatment. One patient discontinued treatment after three weeks, stating she felt better and no longer needed it. Of five that resumed treatment for a second three week period only two definitely report relief from headaches or other symptoms. All five continue with hypertension at levels slightly if at all lower than before treatment or than during the two-week holiday.

Three additional patients were tested and then discharged without Priscol but with conventional treatment. In one after the second 50 mg of the test had reduced blood pressure from 220/140 to around 156/102 weakness

* For convenience this operation will be referred to below as subtotal to total paravertebral sympathectomy. It includes in its denervation sympathetic nerves to the heart and to the adrenal glands.

of the right leg and paralysis of the right arm developed. This subsided after two hours as blood pressure again rose. There was no residual difficulty. The remaining two refused treatment, one did not have lowering of blood pressure with the test but the other had reduction of pressure to normal.

6 *Hypertension treated by Priscol without test or sympathectomy* Four patients received progressively increasing doses of Priscol during a week in the hospital. In three significant lowering of the blood pressure did not occur. The fourth had moderate reduction but Priscol subsequently taken orally at home failed to maintain lowering.

MISCELLANEOUS OBSERVATIONS AND TESTS OF EFFECTS OF PRISCOL ON CIRCULATION

The first two sections of this paper have described clinical aspects of use of Priscol omitting reference to special observations. Effects of Priscol upon circulation determined by observations made during tests or treatment will be presented below. Material will be grouped under method of observation rather than disease.

1 *Oscillometric studies* Oscillometric readings obtained at mid-calf level in five patients with severe arterial obstructive vascular disease varied from four-tenths of a point to 3 points. After effective doses of Priscol, readings were unchanged. Similarly, oscillometric readings in three other patients previously treated by lumbar sympathectomy had not been changed by sympathectomy and were not changed after Priscol. Oscillometric readings in six patients with more normal circulation increased a half point or more after the drug.

2 *Peripheral skin temperature gradient* Skin temperatures were obtained at 10 and 15 minute intervals an hour or more before Priscol and three to twenty-four hours afterward using a McKesson Dermalor. Room temperature could not be kept cool or constant. The gradient of each leg was determined by comparing temperatures just below the umbilicus, over the trochanter, on the medial aspect of the knee, below the medial malleolus, over the dorsum of the foot, and on the tip of the great toe. The gradient of each arm was determined by comparing temperatures over the sternum, over the deltoid, on the lateral aspect of the elbow, over the thenar muscles, and at the tip of the middle finger. Usually, the toes were four to ten degrees centigrade cooler than skin by the umbilicus and the finger zero to four degrees cooler than skin over the sternum.

In general after Priscol this gradient decreased, usually within five minutes after intravenous administration, within twenty minutes after intramuscular injection, and within forty-five minutes after oral administration.

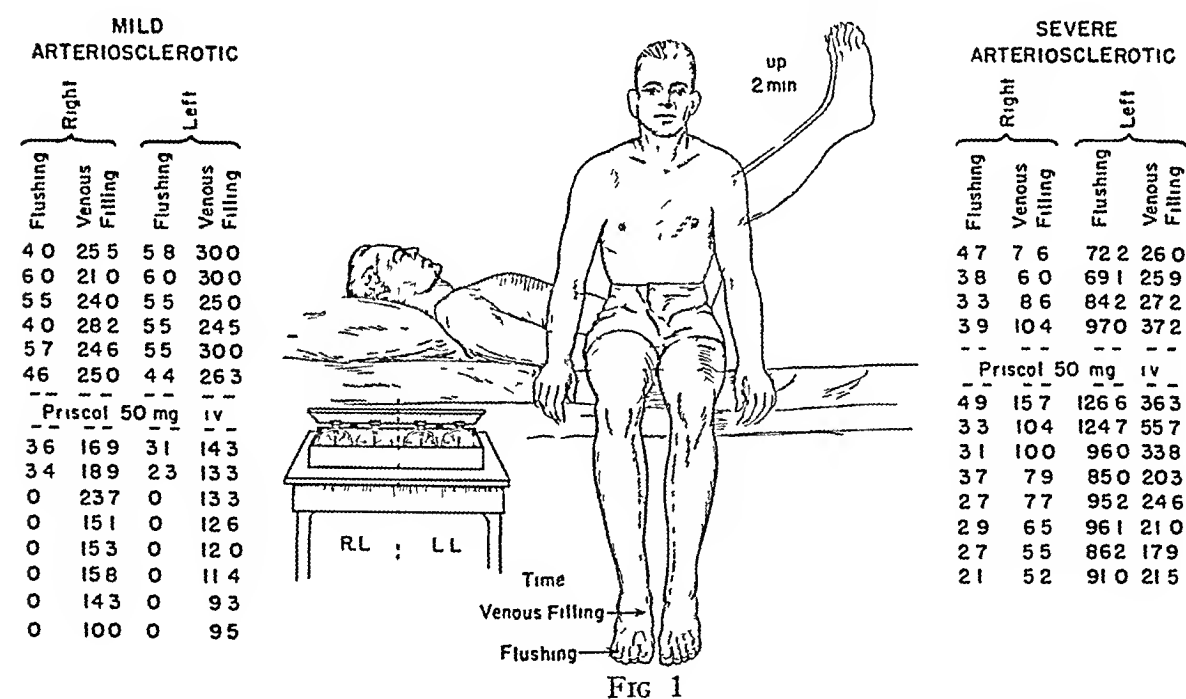
Before Priscol the gradient of five hypertensive and twelve peripheral vascular disease patients was within normal range, and of six peripheral vascular disease patients exaggerated. After 50 mg or more of Priscol skin temperature gradients of the hypertensive patients were abolished, toe tem-

perature equaling temperature by the umbilicus. The gradient of eight of the peripheral vascular disease patients was similarly abolished after Priscol. Another eight had decrease of gradient. Gradient was unchanged after Priscol in only two patients.

Six patients were tested after lumbar sympathectomy. Gradient of the sympathectomized limb had been abolished by the sympathectomy. After Priscol, gradient of the opposite limb without sympathectomy was similarly abolished but temperature of the sympathectomized limb remained unchanged or increased slightly, less than 1°. Similar observations and similar results were obtained by testing upper extremities of three patients with upper dorsal sympathetic ganglionectomy. Five of the above nine patients also had Priscol tests before sympathectomy. In each the loss of gradient by test equaled that produced by sympathectomy.

Patients who were treated continuously, receiving 50 or 75 mg of Priscol every few hours, had moderate increase of foot and toe temperature but did not maintain the marked warming of the foot or abolition of skin temperature gradient accomplished by initial single test doses.

POSTURE TEST-OBSTRUCTIVE VASCULAR DISEASE



3 *Dependent flushing and venous filling* These observations were made after a patient had been lying in bed two minutes with feet elevated at a 45-degree angle (Figure 1). The patient then sat up and dropped his feet over the side of the bed. Time of appearance of pink color, "flushing" of toes, and time of onset of filling of veins of the foot were observed. Approximate observation and timing in 14 patients without serious arterial obstruction indicated that after Priscol flushing and filling of superficial veins occurred more promptly. Color photographs taken in five patients after 15- and 30-second intervals of dependency before and after Priscol confirmed this observation. Accurate timing in 12 patients using four stop-watches also

confirmed the observation. The record presented at the left of Figure 1 and the change after Priscol is typical of most studies. The record at the right of Figure 1 illustrates a typical response to Priscol of the right leg. Flushing time in the left leg is, however, further delayed after the drug. This patient had been admitted for amputation of the left leg. Sympathectomy was probably contraindicated.

4 *Cold pressor test* A "cold pressor test" was performed before and after Priscol in 23 patients with hypertension. Blood pressure was first observed at minute intervals six times or until constant. One hand was then placed in ice water for one minute obtaining pressure readings at 30 seconds and at one minute. Subsequently six additional readings were obtained at minute intervals. Twenty hypertensive patients without sympathectomy were tested. A definite increase of pressure occurred in eighteen. After two 50 mg doses of Priscol an hour apart, the cold pressor test was repeated in nine patients. Pressor response was abolished in five and reduced in four. After a third injection of 100 mg an hour later, 17 patients were tested. The pressor response was abolished in 12, reversed in 3, and reduced in 2. Three patients previously treated by subtotal paravertebral sympathectomy were also tested. A pressor response occurred in each before the drug. After 200 mg it was reduced in 2 and abolished in one.

5 *Breath holding* Breath holding tests were performed in the same group of patients described under the cold pressor test. Blood pressure was recorded six times at minute intervals. Patients then held their breath in expiration as long as possible. Time of breath holding varied from fifteen to thirty-five seconds, average twenty-five. At the moment the patient again took a breath blood pressure readings were obtained. Subsequently pressures were recorded at minute intervals for six minutes. Of twenty hypertensive non-sympathectomized patients tested, eighteen had a definite increase of pressure before Priscol. Ten were tested after two 50 mg intravenous injections of Priscol an hour apart. The pressor response was not changed in one, reduced in five, and abolished in four. After a third intravenous injection of 100 mg, seventeen patients were tested. The pressor response was reduced in three, abolished in thirteen, and reversed in one. Three patients previously treated by paravertebral sympathectomy were also tested. Two had a positive response which was reduced but not abolished after 200 mg.

6 *Blood pressure—supine position* The effect of intravenous administration of varying doses of Priscol upon blood pressure of patients with hypertension and of patients with peripheral vascular disease but with relatively normal pressure was determined. Twenty-two patients with hypertension were tested. During one hour after injection of 50 mg, fifteen had no change of pressure, three moderate reduction, and four moderate increase. A second injection of 50 mg was then given. During one hour afterward fourteen had no change, seven moderate reduction and one reduction to normal values. Seventeen patients received a third injection of 100 mg or

altogether 200 mg of Priscol. Blood pressure remained unchanged in five, moderately reduced in four, and reduced to normal in seven. One patient had temporary reduction below normal to shock levels but recovery was spontaneous. Temporary pressor responses not exceeding 20 mm systolic were observed in four of the above 22 patients during the first five minutes after injection.

Three patients with hypertension persisting after paravertebral sympathectomy were similarly tested. After 50 mg, pressure was unchanged in two and increased in one. After 100 mg, it was slightly reduced in two and increased in one. After 200 mg, it was reduced in two and reached normal values in one.

Thirteen patients with peripheral vascular disease and essentially normal blood pressure were tested. During one hour after 50 mg nine had no change, one slight reduction, and three moderate increase. Nine were tested after 100 mg. Six had no change, one moderate reduction, and two moderate increase. Three were tested after 150 mg. Pressure remained unchanged in six and was moderately reduced in three. Temporary pressor responses not exceeding 18 mm systolic were observed in three of these thirteen patients during the first five minutes after injection.

7 Blood pressure—standing Blood pressures were obtained in sixteen patients with hypertension an hour or more after the third injection, or a total of 200 mg of Priscol. After standing several seconds to a minute, twelve had reduction of pressure to the point of syncope. Four had marked postural hypotension although not to syncope. Blood pressures while standing were also obtained twice daily in ten hypertensive patients during a week or more of treatment in the hospital. Each persisted with moderate postural hypotension but not to syncope. A moderate postural hypotension also usually persisted in patients treated at home a month or more. Patients with normal blood pressure and with peripheral vascular disease also developed marked postural hypotension after injection of 100 to 200 mg.

8 Pulse rate Pulse rates were determined frequently during tests of twenty of the group of patients with hypertension. Transient increase of rate during the first two or three minutes after each injection occurred in sixteen patients. Persisting rate during the hour following each injection varied from patient to patient. In ten after 50 mg there was no change, in eight, an increase up to ten beats per minute, and in two an increase of ten to twenty. After the second injection, altogether a total of 100 mg, pulse rate remained unchanged in five, increased up to ten per minute in six, increased ten to twenty in six, and increased by twenty to thirty in three. In 19 patients after a third injection or altogether 200 mg, pulse rate remained unchanged in five, increased up to ten per minute in nine, increased ten to 20 in three, and increased 20 to 30 in two.

Three patients were tested after heart and adrenal denervation by paravertebral sympathectomy. Pulse rate did not change after 50 to 100 mg. After

200 mg the rate of two patients remained unchanged and of one increased four beats per minute

Patients receiving continuous treatment ordinarily have a normal pulse rate. A few describe occasional sensation of rapid beating of the heart lasting a few minutes

9 *Pupil* Temporary dilatation of the pupil was observed after injection of 50 mg in four of 20 patients with hypertension, and after 100 mg in two. Dilatation did not occur in three patients with paravertebral sympathectomy which includes sympathetic denervation of the head. In all patients after all doses, pupils appeared normal, dilated in darkness, and constricted in light. Patients read easily throughout test periods even after a total of 200 mg of Priscol.

10 *Respiration* After intravenous injection of small or large doses of Priscol a few patients described momentary "shortness of breath" and took several deep breaths. Persisting respiratory rate of twenty-four patients accurately timed did not change in nineteen and was increased from two to four per minute in five.

11 *Response to adrenalin* Response to adrenalin was tested in one patient with hypertension. Control blood pressure was around 206/108. After 10 drops intravenously of a mixture of 200 cc of saline and 1 cc to 1000 adrenalin pressure increased to 234/92. After twenty drops it increased to 248/100 and again after 8 drops to 240/100. This patient was then treated for three days by hypodermic injection of 50 mg of Priscol every 4 hours. During the second day of treatment adrenalin was again administered using a similar and freshly prepared solution. Sixty drops were injected within two minutes. Blood pressure decreased from around 218/116 to 200/78. Twelve hours after Priscol was discontinued 10 to 23 drops of a similar solution again produced marked pressor responses.*

12 *Response to anesthesia* A 58-year-old-man patient suspected of having a pheochromocytoma or a paraganglioma was given three successive intramuscular injections of 50 mg of Priscol during two hours preceding exploratory laparotomy. Ethylene, ether and curare were used for anesthesia. During two and one half hours under anesthesia and during the administration of 750 cc of whole blood, 500 cc of plasma, and 800 cc of 5% dextrose in saline, blood pressure varied from around 110/160 to 170/110. There was no evidence of reflex change of pressure from manipulation or traction of abdominal viscera or of increased pressure when adrenal glands were inspected and palpated. No tumor was found.

13 *Temperature gradient of pedicle skin tubes* Three patients with skin tubes in various states of preparation or transplant were given Priscol intramuscularly. One tube had been raised from the lower leg but had both ends attached. After 69 mg of Priscol temperature in the center of this graft rose 1.6° C. A second tube had been raised from the chest to the ear, but was

* A preliminary report (25) has described additional experiments in man demonstrating adrenolytic action of Priscol. Results will be amplified in another paper.

still attached to its site of origin. Temperature in the center of the graft rose 1.4°C after 65 mg of Priscol. The third tube had been transplanted to the right hand and then moved from the site of origin to a defect of the lower lip, thus eliminating its original nerve supply. Temperature rose 1.9°C after 53 mg of Priscol. Color photographs of each tube clearly demonstrated increased redness.

14 *Cardiac output* Observations have been made on three patients by J. B. Hickam, who will report details and further studies. All readings were taken in the horizontal position. Two patients had mild hypertension and one thromboangitis obliterans involving four extremities. No patient had clinical evidence of impairment of cardiac function. Cardiac outputs were determined by the Fick principle using the technic of cardiac catheterization. Patients were tested under basal conditions and again 30 minutes after 50 mg of Priscol intravenously. In two, cardiac output did not change. In the third, an apprehensive patient with a high control value, the output decreased to a normal level after Priscol. One patient received a second injection of 150 mg of Priscol one-half hour after the first. His output one-half hour later was unchanged. Response to five minutes of leg exercises was also tested before and one-half hour after 50 mg of Priscol. For equal amounts of exercise the cardiac outputs were identical.

15 *Urinalyses and blood counts* Urinalyses were obtained in seventeen patients before, during, and at the end of continuous treatment with Priscol for a week or more in the hospital. The longest period of treatment was nineteen days. Changes or abnormalities did not occur. Hemoglobin, red and white blood counts were similarly obtained in fifteen patients, in four instances supplemented by differential counts. With one possible exception changes or abnormalities did not occur. In one patient the white blood count dropped from 9,000 before Priscol to 3,110 after ten days on the drug. Two days later while receiving the drug the count was 5,550 and one month after discontinuing treatment it was 9,000. The only other drug administered with the Priscol in this patient was sodium pentobarbital, 1 Gm the two evenings before the low count. Eleven patients checked while receiving Priscol at home for periods up to seven months have had no significant change in urinalysis or red and white blood count.

DISCUSSION

Favorable reports of use of Priscol for a variety of peripheral vascular diseases have appeared in European and South American literature. Our clinical experiences with this drug during periods of treatment not exceeding nine months have confirmed these reports. Single doses of 25 to 75 mg evidently with few exceptions produce changes in circulation of limbs equivalent to those produced by sympathetic block or sympathectomy. Continuing treatment by this dose schedule maintains benefit but does not entirely equal the effect of sympathectomy. Results in treatment of Raynaud's disease have been encouraging and unless evidence of toxicity or tolerance develops, sympathectomy is no longer recommended by us. Results in treatment of vasospastic

ischemic extremity problems and causalgia states have been encouraging. Results in treatment of thromboangitis obliterans and arteriosclerotic peripheral vascular disease are less easily evaluated. At present treatment is limited to patients refusing sympathectomy or those with complications contraindicating sympathectomy. Treatment has been and is currently being offered to patients with peripheral vascular disease complicated by coronary heart disease. Nevertheless, theoretically at least, harm may develop from drug action on the heart. Of 9 patients with known progressive generalized arteriosclerotic vascular disease and coronary involvement tested or treated by Priscol two developed myocardial infarction. Our clinical impression that this would have occurred had Priscol not been used cannot be established without further experience. Patients without known coronary heart disease have not as yet developed cardiac complications. Doses of Priscol over 75 mg should, however, be avoided in patients with known obstructive disease of coronary or other arteries since reduction of blood pressure might occur with adverse effects.

A test intravenous injection of 50 or 75 mg of Priscol may aid prediction of immediate results of sympathectomy in patients with peripheral vascular disease.

Attempted treatment of hypertension by Priscol in dose ranges up to 75 mg every two hours has yielded encouraging results in only a few instances. Similarly use of a Priscol test for hypertension or of Priscol treatment a week or more in the hospital has not aided prediction of results of sympathectomy.

Oscillometric readings at calf level in patients with marked organic arterial disease were not changed by Priscol. It is our experience that low readings are seldom altered during the first week after surgical sympathectomy. Increase of readings occurred after Priscol in patients with less arterial obstruction. Skin temperature gradient of arms and legs was usually decreased or abolished after Priscol test doses. Warming of hands and feet was less marked during continuous treatment. Evidence of more rapid dependent flushing and venous filling of toes and feet after Priscol adds to evidence that blood flow through extremities may be increased, arterial supply permitting.

It is of interest that goose flesh frequently would be observed over the body after Priscol, also, it appeared on the skin of sympathectomized limbs. This would indicate a peripheral effect. Sweating, frequently produced by doses of Priscol of more than 75 mg, never appeared in sympathectomized areas. This would indicate dependency on innervation.

Doses between 100 and 200 mg blocked pressor responses to placing a hand in ice water or to breath holding. Cold pressor block is conventionally believed an indication of complete sympatholysis. We have, however, observed definite pressor responses in patients evidently totally sympathectomized. Block of pressor response to breath holding is possibly an indication of sympatholysis. Postural hypotension develops after sympathectomy for hypertension. Postural hypotension observed after large doses of Priscol equals or exceeds that after subtotal to total paravertebral sympathectomy.

Ordinarily, injection of Priscol did not dilate pupils. Dilatation did occur in a few patients but never occurred if the pupil had been sympathectomized. It would seem that dilatation when observed was caused by apprehension or an alarm-type of reaction. Rate of respiration was not significantly altered even by large doses, and there is no indication except for block of pressor responses of the breath holding tests that respiratory mechanism is effected.

Occasional observations in the absence of sympathetic innervation have indicated that Priscol may have a peripheral and perhaps histamine-like effect. Patients who have had sympathectomy, for such diseases as Raynaud's, state that the drug makes their hands feel warmer and more comfortable. One completely transplanted skin tube increased in temperature after Priscol. It is possible that a peripheral effect might be related to block of action of circulating adrenalin. Presumably, all of the hypertensive patients treated by para-vertebral sympathectomy had denervation of both adrenal and cardiac areas. Nevertheless, blood pressure lowering was occasionally produced by Priscol. It could also be assumed that block of circulating sympathin might permit dilatation of denervated vessels. From experimental evidence in animals, however, it would appear that Priscol may have histamine-like action in addition to its potent adrenolytic and sympatholytic properties.

CONCLUSIONS

1. Priscol in doses of 25 to 75 mg. is a useful adjunct to treatment of many peripheral vascular diseases or circulatory disorders and in this dose range usually is tolerated with few side effects.
2. Priscol in test doses of 100 to 200 mg. has lowered blood pressure of many patients with hypertension but sustained treatment by smaller doses has aided only a few.
3. Priscol has adrenolytic and sympatholytic properties in patients and may also have some histamine-like effect.

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DISCUSSION —DR GEORGE D LILLY, Miami, Florida I should like to compliment Doctor Yeager upon his presentation of this most timely subject I agree with him that we must stress the importance of thorough sympathectomy

Due to the fact that I live in a semi-tropical climate, I probably see more failures than most people, because so many of these patients come south in the winter to avoid some of the misery which cold weather produces in persons suffering with peripheral vascular disease It has been most discouraging to me to examine many people who have had little or no improvement following sympathectomy, only to find that they are sweating profusely down to the knee or lower I feel that inadequate sympathectomies are giving the procedure a bad name Too many of these procedures have been turned over to house officers with inadequate experience, and too many of them have been attempted by persons who have not familiarized themselves with the bizarre anatomy of

the lumbar sympathetic nervous system Our own hospital pathologist, after examining some alleged lumbar sympathectic trunks, has had to make diagnoses of lymphatic chains, fascia, fat and connective tissue, and genitofemoral nerve

I feel that a great many so-called regenerations are really not regenerations, they most probably represent cases who had an inadequate sympathectomy in the first place I have had the misfortune of trying to operate on some of these people again As most of you know, this is a most difficult undertaking, when one attempts to go back through the same retroperitoneal incision I have found, however, that in many cases an adequate sympathectomy can be accomplished by resecting the distal half of the twelfth rib and approaching the lumbar sympathetics from the sub-diaphragmatic region, as one does in a Smithwick type of sympathectomy In this way, the upper lumbar sympathetic trunk can be identified, and the trunk then followed down into the scar tissue of the previous operation

BOOK REVIEW

Text book of General Surgery, 5th Edition 1948 Warren H Cole, M D , and Robert Elman, M D , New York, D Appleton-Century Co , Inc.

This excellent text book of general surgery has been revised and brought as nearly up to date as is possible in a rapidly progressing surgical world It begins with a chapter on the history and physical examination of the surgical patient, then proceeds to develop chapters on the basic surgical principles of tissue repair, asepsis and antisepsis, infection, chemotherapy, wound healing, infusions, anesthesia and convalescence Other chapters describe the principles of the management of amputations, thermal injuries, diabetes in surgical patients and the recognition and management of shock The authors have emphasized the pathogenesis and important physiologic, biochemical, and bacteriologic processes that are associated with these conditions

The chapter on neoplasms and cysts classifies and describes surgical pathology, general principles of management and prognosis of surgical neoplastic pathology and photomicrographs of common neoplasms

The chapters dealing with surgical conditions in specific anatomical regions or systems relate principles of diagnosis, pathogenesis, surgical pathology, and, in appropriate places, the physiological, chemical and bacteriological considerations associated with the disease and its surgical treatment Principles of preoperative and postoperative management and general surgical procedures are described adequately, but the details of technical procedures are quite properly omitted from this single volume text book of general surgery Appropriate Diagrams and graphs illustrate important principles and there are many well placed illustrations of surgical pathologic conditions

The final chapter on military surgery demonstrates the organization of general surgical services under wartime conditions and describes the principles of the surgical care of the usual injuries encountered in World War II

Many excellent surgical authorities have contributed to the material in this text, presented with exceptional clarity from the viewpoint of general surgeons The style is brief and concise This is a superb book of general surgery for medical students It is an excellent modern general surgical reference book for general practitioners, surgeons and teachers of surgery

CARCINOMA OF THE BREAST*

WM PERRIN NICOLSON, JR

AND

EDGAR D GRADY

ATLANTA, GA

PESSIMISM continues to dominate the thoughts of the majority of those dealing with carcinoma of the breast. Education of the laity has brought the patient in somewhat earlier. The use of radiation, either by roentgen-ray and/or radium, either pre- and/or postoperatively, has shown some improvement in results in the hands of most workers. The recent use of hormones may add a ray of sunshine to the dark gloomy picture that has existed. In spite of these improvements, the salvage rate has not materially increased. A statistical study is, of necessity, a dry and dull one but it is only by comparing honestly presented figures in many large groups of cases that we can hope to make progress.

This paper will present a study of 905 cases of carcinoma of the breast seen at the Steiner Cancer Clinic in Atlanta, Georgia, between its inception in 1924 and January 1, 1942. One of us (WPN) reported on the first 261 of these cases, of which 78 were "primarily operable", according to the dicta laid down by the late Burton Lee. In addition to these, this report will include those cases seen since June 1, 1930, and before January 1, 1942, during which time, 644 cases were admitted. A total of 417 were treated surgically. In this latter group, the primarily operable cases have not been segregated. There were 76 cases in which palliative surgical procedures were carried out and 341 in which those procedures were carried out with the hope of obtaining a good result. Consequently, this last series will not show as good figures as the first. One should specify how his figures are obtained. These cases were both negro and white in a low income group, no private cases being included in the series. They were, as a rule, in a more advanced stage than those seen in private practice and the follow up is not as adequate as is possible with private patients. Of the 417 cases, 358 were followed for a period of five years or more. Sometimes these follow ups were obtained through the bureau of vital statistics and in many instances, it could be ascertained that the patients had died but, whether or not they had a recurrence at the time of their death, could not in every case be determined. In calculating the percentages, those cases which have been lost sight of were not included in the figures. The operations were performed by twenty or more surgeons, in many instances the resident surgeons. The type of operation was not the same in each case. This study was begun with no idea of proving or disproving any pet theory but to evaluate our work and see where we stood.

In most instances, these patients received a preoperative cycle of roentgen-ray treatments, followed in approximately two or three weeks by a radical

*Read before the Southern Surgical Association at Hollywood Beach, Florida, Wednesday, December 10, 1947

CARCINOMA OF THE BREAST

mastectomy In most cases a postoperative cycle of roentgen-ray treatments was given In selected cases simple mastectomies were performed This study will analyse the occurrence and results from many angles

Chart I illustrates the occurrence as to age groups These varied from two who were less than 25 years of age to one over 80 years of age It is surprising to note that the results in the third decade were practically the same as those in the fourth, fifth, and sixth We had previously considered those cases occurring in the early age groups as having much poorer chances

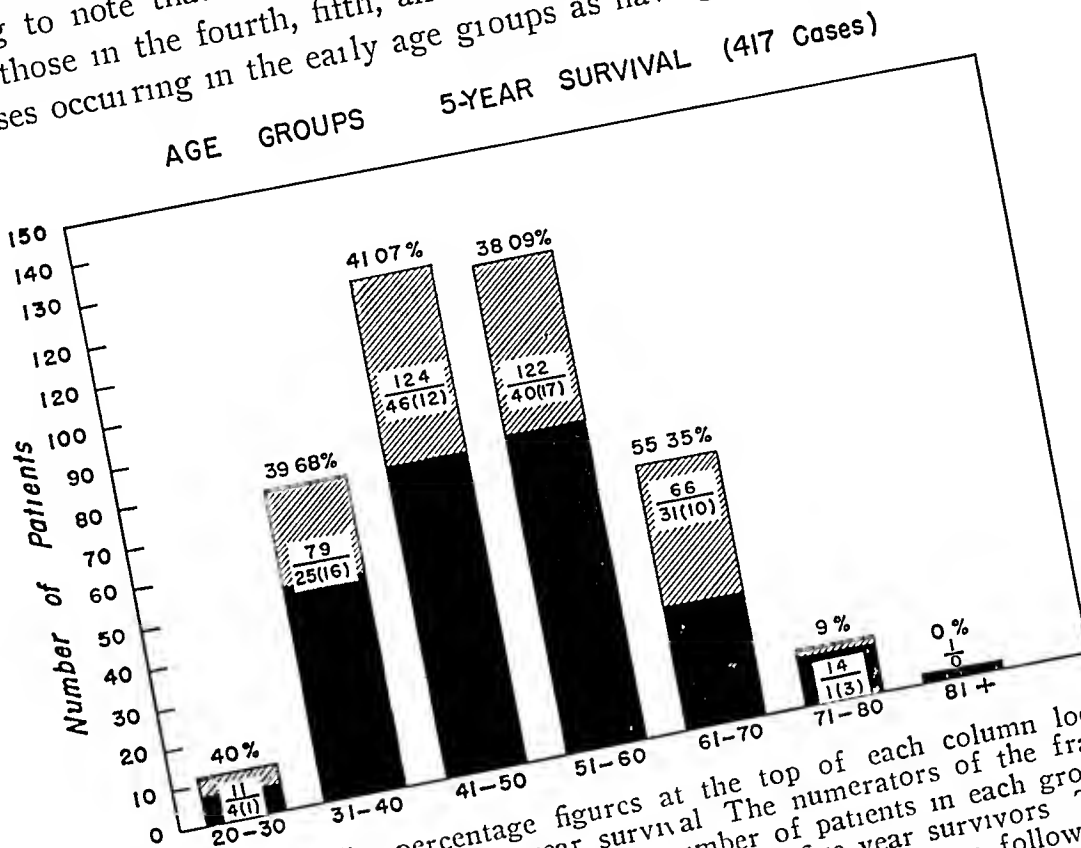


CHART 1—The percentage figures at the top of each column look forward to the per cent five year survival The numerators of the fractions in the columns indicate the total number of patients in each group The denominators indicate the actual number of five year survivors The figures in parenthesis refer to the patients who were lost in follow-up They are not included in the calculations of the percentage of five year survivors The solid black portions of the columns indicate the number of patients died or lost in follow-up in each group The shaded portions of the columns indicate the number of five year survivors in each group

than the later ones The best results were obtained in the seventh decade and there is then a very sharp decline in the last two Table I illustrates the marital status in 410 cases in which this information was available There is nothing remarkable in this series except that those persons who had not been married show a 5% better five-year end result than those who had been We hope that this is not a contraindication to marriage

Chart II indicates the "chief complaint" occurring in these cases As would be expected, by far the largest group is that with a lump in the breast The next group is a painful lump in the breast, whereas, pain is present in only 5% of the cases as the chief complaint This is in accord with practically all series that have been reported and is encouraging in that it can be used as a means of consoling the large number of frightened women who come in

CHIEF COMPLAINT (408) Cases)

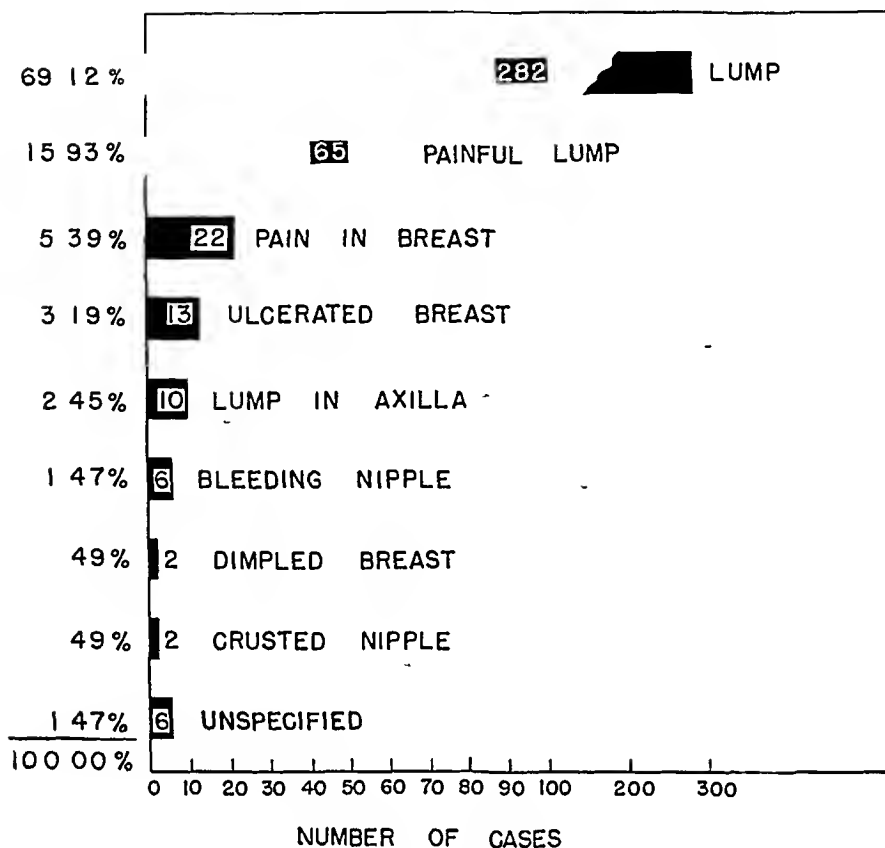


CHART 2—Chief complaints of cases

DURATION OF CHIEF COMPLAINT (417 CASES)

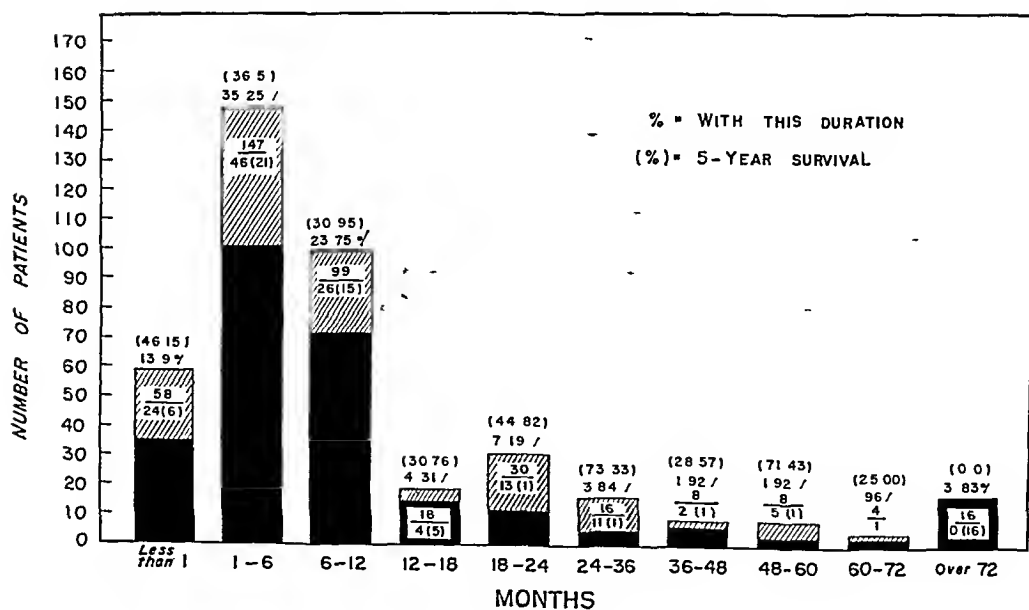


CHART 3—Fraction with each column same as in figure one

CARCINOMA OF THE BREAST

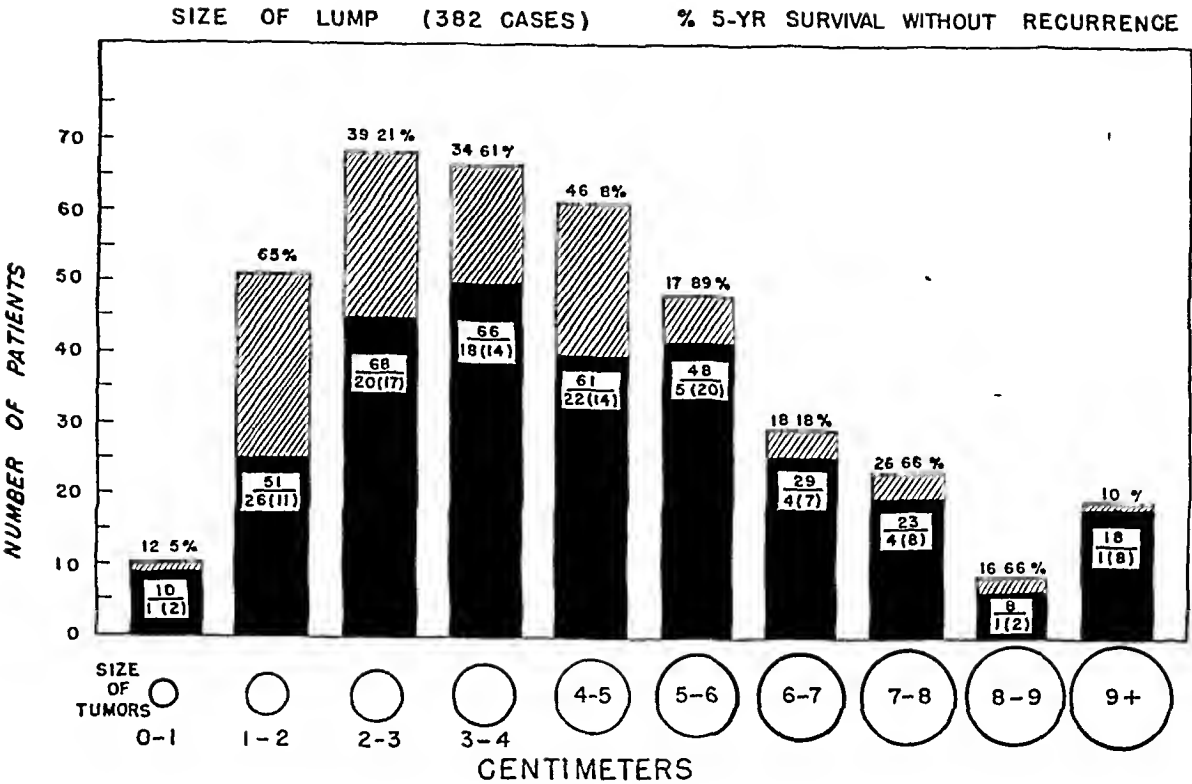


CHART 4—Size of lumps in breasts

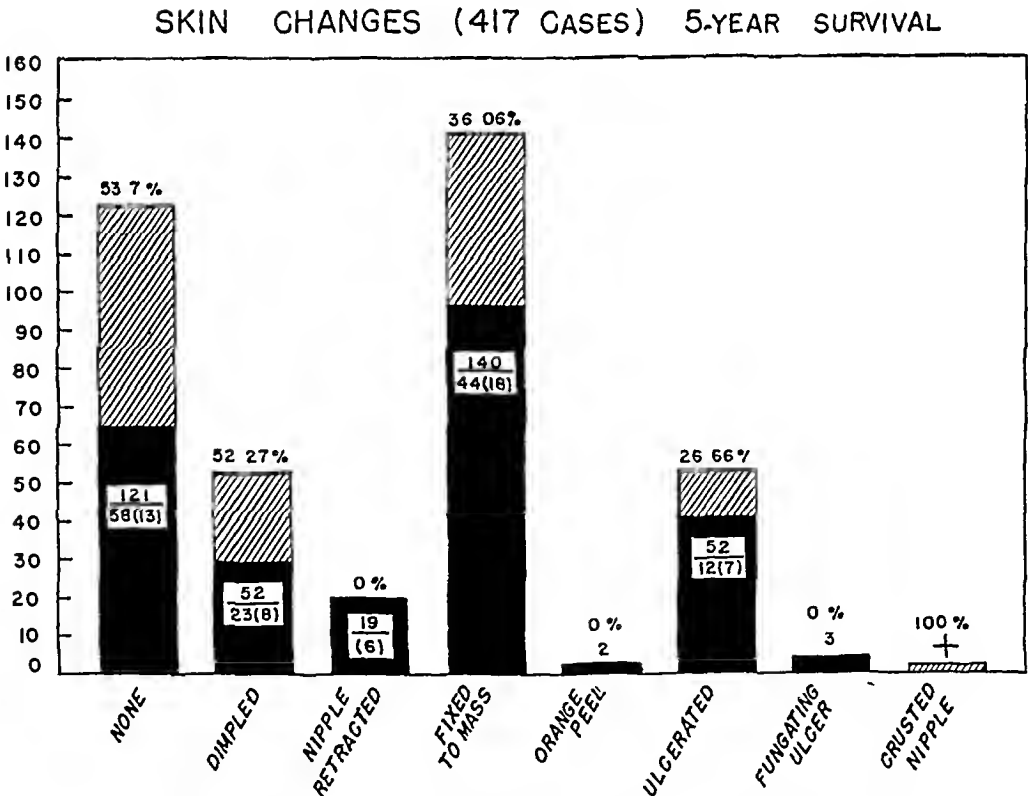


CHART 5—Results obtained in 390 cases in which changes in skin were noted

because of pain in their breast Chart III records graphically, the duration of the chief complaint It is discouraging to note that in over 25% of the cases, the chief complaint had existed longer than a year, and in less than 15%, was the patient seen in less than one month after the chief complaint

appeared. As would be expected, the results in these groups vary directly with the duration of the chief complaint until a period of 24 months has elapsed and then there's a sharp rise in survival to be accounted for, presumably, by the fact that any growth which has existed over two years, must of necessity, be of a relatively low malignancy.

A history of cancer in the family was not obtained in 76.74% (321 cases), in only 12.23% (51 cases) there was history of cancer other than that

TABLE I—*Marital Status (410 cases)*

	Married 193	Single 62	Widowed 155
5 Year Survival	69 (40.82%) (24 not followed)	23 (45.09%) (9 not followed)	52 (40%) (25 not followed)

of the breast, and in 6% (25 cases) there was history of cancer of the breast.

There was no history of injury to the breast in 80% (331 cases), while in 5.5%, there is history of an injury followed by a tumor, and in 5.75%, history of recovery from an injury and later developing a tumor. In 4.31%, a history of a breast abscess occurring earlier was obtained, and in only 1.5% (6 cases) was there a history of an injury followed by an accentuation of the growth of the tumor.

A discharge was noted from the nipple in many cases. It is considered significant, especially if bloody. In 78% (368 cases) there was no history of discharge. In 5.5% (23 cases) there was history of a bloody discharge,

TABLE II—*Relation to Menopause (360 cases)*

	Premenopausal	Menopausal	Postmenopausal
	134	8	218
Survived without Recurrence 5 Years or More	42 (42%)	3 (50%)	50 (31.44%)
Not followed	(34)	(2)	(59)

TABLE III

Type of Operation	Radical		Simple		Simple C Removal of Axillary Nodes	
Healing of Wound	Pre-op X-Ray	No Pre-op X-Ray	Pre-op X-Ray	No Pre-op X-Ray	Pre-op X-Ray	No Pre-op X-Ray
Less than 7 days	3.08	none	5.71	33.33	none	none
8-10 days	4.32	7.7	5.71	none	none	none
11-14 days	11.78	7.7	25.71	22.22	none	none
15-21 days	24.7	26.92	11.42	22.22	28.57	none
22-30 days	17.81	15.4	5.71	22.22	none	none
31-60 days	27.16	23.1	20.00	none	71.43	100%
Over 60 days	14.2	19.23	14.3	none	none	none
Infection						
Present	17%	11.86	18.18	30	36.36	16.67
Absent	83	88.14	81.82	70	63.64	83.33

CLINICAL NODES IN AXILLA (417 CASES)

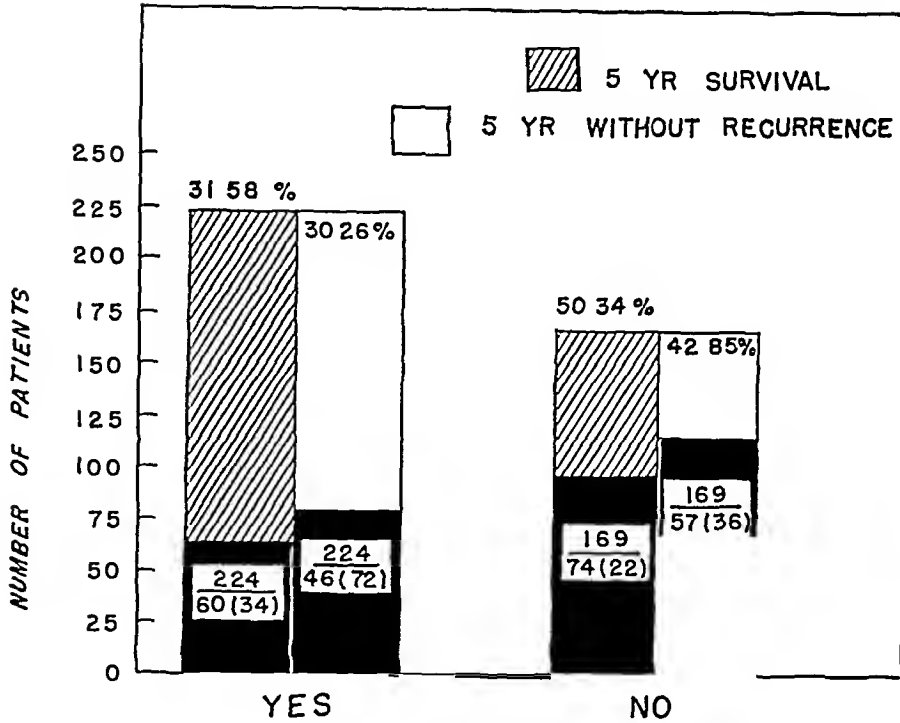


CHART 6—Occurrence of nodes in the axilla

AXILLARY NODES (334 CASES)

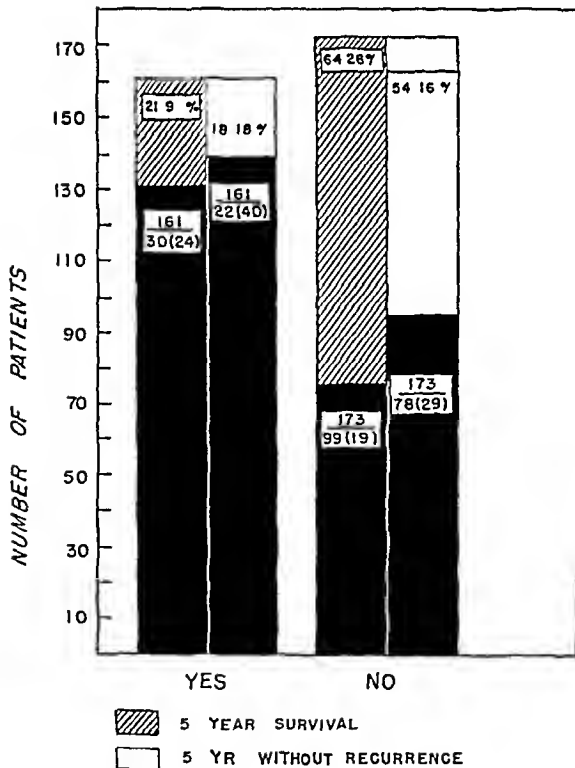


CHART 7—Occurrence of nodes in the axilla

in only one-half of 1% was a purulent discharge noted, and in 3% (12 cases) had a serious discharge, and in all of these cases the chief complaint had been something other than a discharge

In approximately 94% (390 cases) there was a history of having had a lump in the breast. In 19, there was no history of lump in the breast.

The duration of the history of a lump varied greatly. In 11% (46 cases) it had existed for less than one month, in 34% (142 cases) from one to six months, in 22.5% (94 cases) from six to twelve months, and then we note, progressively, 4.5% between twelve and eighteen months, 6.5% between eighteen and twenty-four, 3.5% between twenty-four and thirty-six, etc., until we find that in nearly 25% of the cases, the lump had

existed over a year and up to six years. It is alarming to think that in this day of enlightenment and cancer education, a fourth of the patients would have a lump in their breast for over a year and some as long as six years without consulting a doctor. This is certainly discouraging.

The question of whether or not pregnancies have occurred is an important one. In 72% (331 cases) there had been no history of pregnancy. No conclusions should be drawn from these figures unless one also knew the percentage of the same age group in the general population who undergo pregnancies. About 14% had had one pregnancy and a similar number had had two. Only 9% had had three pregnancies, and then the number greatly decreases to 2% having had seven pregnancies and nearly 5% had eight. 72% had had no miscarriages, 10% one miscarriage, 4.8% two miscarriages, 2% had had three. The duration of the lactations varied. Four had lactated for

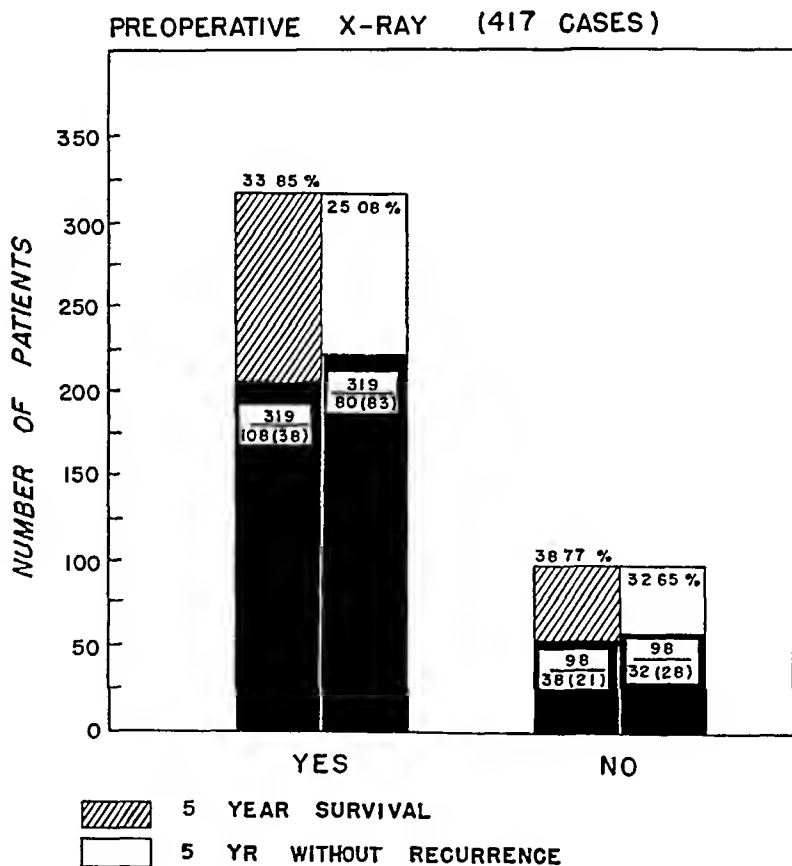


CHART 8—Results in relation to whether or not pre-operative radiation was given

less than two months, 27 from two to 12 months, 24 over 12 months, and in 185, the period of lactation was not specified. One of us (WPN) has previously emphasized the importance of lactation as a prophylactic measure in cancer of the breast. Drabble examined the udders of all cows slaughtered at the State Abattoir at Homebush Bay, New South Wales, Australia, from 1926 to 1929 and found not a single instance of carcinoma of the udder, and epitheliomata in only 3 cows. Trout, in a paper before this association quoted this work, as well as that of Bagg at Memorial, in support

of the feeling that stagnation and failure to lactate contributed to the development of mammary carcinomas. The present day interest in the effect of hormones on cancer in general and on cancer of the breast in particular, would emphasize this group of cases. No consideration of hormonal therapy can be included in this report because none had been administered at Steiner Clinic previous to 1942. It is interesting, however, to note any discrepancies in the menstrual history of these patients since this would tend to indicate some effect from hormones. In 50% of the cases, the menstrual history was perfectly normal, and of these, 39% lived five years without recurrences. In 2%, there was history of a painful breast at menstruation and in these cases, only 14% survived five years without recurrences. In 3%, an hyster-

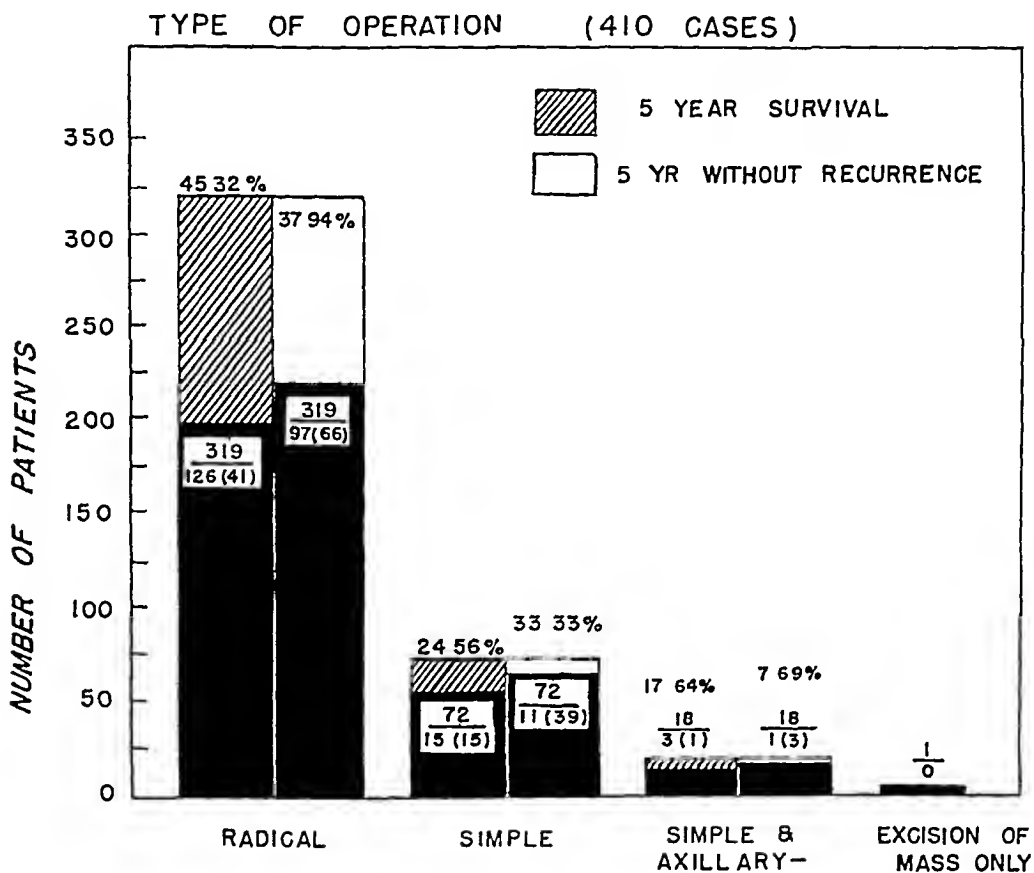


CHART 9—Types of operations performed with five-year survival rate and the survival without recurrence in each type of operation

ectomy had been performed, and none of these survived five years without recurrence. Other abnormalities in their menstrual histories were noted in 5.25% and of these, 28% survived without recurrences, and in 40%, the menstrual history was not recorded. Table II records the occurrence in reference to the menopause. It requires very little comment. Undoubtedly, the lower survival rate in the post-menopausal cases is occasioned by the fact that so many of these were cases in which only a palliative operation was performed, and in those occurring during the menopause, there was such a small number that the percentage of five year survivals can vary widely.

Chart IV records graphically the size of the lump in the breast. No explanation can be offered for the small percentage (12.5%) of cases in which a lump less than one centimeter in diameter survived five years without recurrence. As would be expected, the results in the others varied directly in proportion to the size of the lump until it was between four and five centimeters when there is a slight increase in the five year salvage percentage and then a progressive drop.

Chart V records graphically the results obtained in 390 cases in which

PERCENTAGE OF SURVIVAL

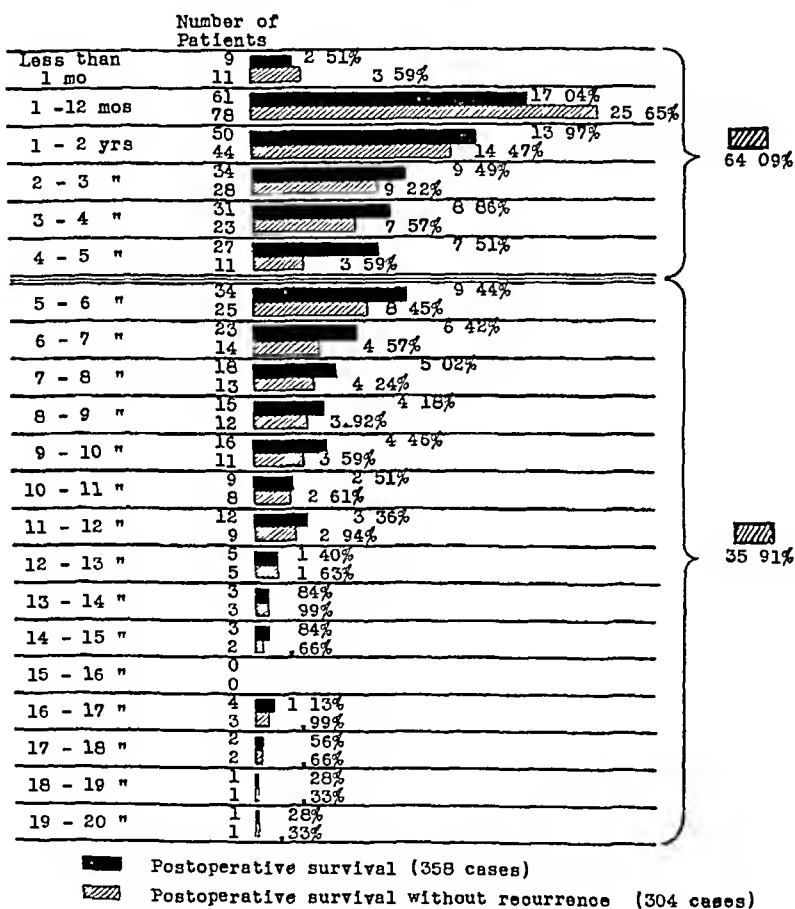


CHART 10—Length of life after operation, with and without recurrence

the changes in the skin were noted. The remarkable things to be noted here are that there were no five-year survivals without recurrence in any of the cases in which there was a retraction of the nipple, an orange-peel effect of the skin, or a fungating tumor without ulceration. Fixation of the mass to the skin produced a slight decrease in the five-year end results but dimpling of the skin apparently had no effect on the result obtained.

Charts VI and VII present graphically the occurrence of nodes in the axilla, noted clinically or by the pathologist. In those cases in which a clinical presence or absence of the node was recorded, there was not as great a difference in the five-year survivals without recurrence in those without nodes and those with nodes, as there was in those found by the pathologist. In the latter group, these figures correspond very closely to those in other series, namely approximately 20% in which the nodes were noted by the pathologist, and about 60% in those in which there were no nodes.

Chart VIII records graphically the results in relation to whether or not pre-operative radiation was administered. It is discouraging to note that

TUMORS INVOLVING THE BREAST

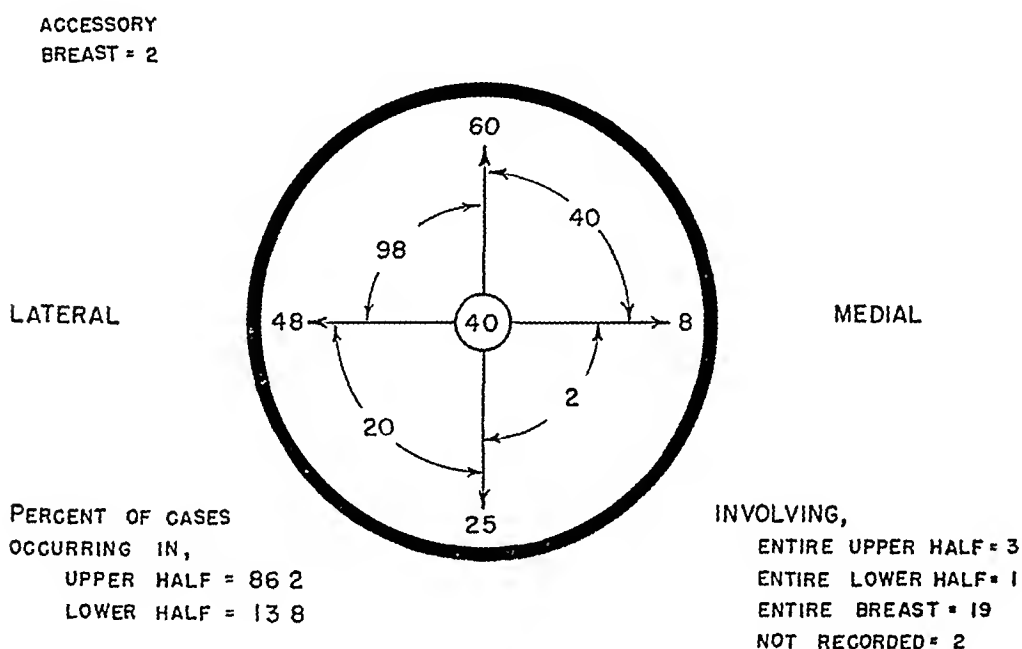


CHART XI—Location of the tumor

apparently a higher percentage of cases did well who had no preoperative radiation. We feel that the explanation lies in the fact that so many of those who were considered hopeless and in which palliative operations were performed, received pre-operative radiation. In spite of these figures, it is the opinion of the Steiner staff that preoperative radiation is beneficial. All of the far advanced cases, particularly those with ulcerated lesions, received pre-operative radiation. The delay between the completion of the radiation and the operation in this group of cases, was between 1 and 14 days in 25.8% (67 cases), between 15 and 28 days in 46.3% (144 cases), and over 28 days in 32.15% (100 cases). It should be stressed, in this connection, that one should decide the primary operability of a case before administering any radiation, and having made that decision, should not later alter it. Many cases obviously primarily inoperable, may later appear to become operable following radiation. A delay in operating is lamentable but we feel that the

good accomplished by radiation, namely the destruction or inactivation of the cancer cells plus the blocking of the lymphatics by scar tissue, outweighs the delay

The occurrence of an infection was recorded in 18.38% of the 359 cases in which this fact was noted. This, of course, is a very unusually high rate of infections. However, there were 52 cases in which an ulcerated lesion was present. In many instances, the apparent infection was really a slough produced by the electrosurgical unit used in many cases. The use of this unit, undoubtedly, increases the instance of sloughing and infections and delays wound healing. If 52 cases who had sloughing lesions are deducted, the infection rate drops to 4%. Table III records that the infection

TABLE IV—*Use of Skin Grafts (364 cases)*

1	None used	89.29%
2	Primary grafts	2.74%
3	Secondary grafts	7.97%

TABLE V—*Wound Healing (245 cases)*

	Per cent	
Less than 7 days	4.49	} 24.49
8—10 days	4.49	
11—14 days	15.50	
15—21 days	22.89	
22—30 days	13.06	
31—60 days	25.70	
Over 60 days	13.87	

rate is apparently higher in those undergoing radical mastectomy who had had preoperative radiation than those who did not have it, but it is distinctly higher in those who did not have preoperative radiation and who underwent a simple mastectomy. Here, the group is such a small one that the figures can easily be distorted.

Table IV records the percentage of cases in which skin grafts were employed. Not as many skin grafts were used in this series as are reported in others for several reasons. In the first place, following preoperative radiation or the use of the electrosurgical unit, the primary skin graft is much less likely to live. For the same reason, failures to obtain a living graft in the secondary grafts were frequent.

Table V records the length of time required for wound healing in the 245 cases in which this information was available. Approximately 25% of the wounds were healed in 2 weeks, another 25% in an added week. The delay in wound healing is undoubtedly due to three factors, pre-operative radiation, the use of the electrosurgical unit, and failure to use skin grafts primarily.

TABLE VI —Pathologic Diagnosis (414 cases)

Diagnosis	%	Axillary Nodes		Type of Operation						5-Year Survival			5-Year Survival without Recurrence			
		Yes	No	Radical	Sample	Sample c axillary nodes	Excision of mass	Radical	Sample	Sample c axillary nodes	Excision of mass	Radical	Sample	Sample c axillary nodes	Not re-corded of mass	
Serrrhous, Sclerosing or Fibrous	26 81	45 45	54 55	83 03	10 71	5 35		12 53	10	16 67		32 5	none	none	100	
Circinoma—Simplex	24 18	50	50	74 75	16 44	4 85		44 77	6 25	40%		37 1	none	33 33	0	
Adeno-circinoma	20 29	53	47	72 43	21 62	5 4		55 33	45 45			46	50	none	none	
Alveolar	10 38	63 33	36 67	66 67	28 57	2 38		52 17	33 33			35 83	16 67			
Duct—Tubular	9 66	22 22	77 88	84 61	12 82	2 56		52 13	100			55 56	100			
Medullary	1 93	75	75	100				40				66 67				
Gelatinous	1 93	57	43	75	12 5	12 5		75				75				
Padgets	2 17	14 28	85 72	4 45	5 55			33 33	60			33 33	75			
Comedo	1 2	50	50	60	20			33 33								
Sircinoma	96	33 33	66 67	50	25			100				100	100			

TABLE VII —Postoperative Use of Arm (265 cases)

	Radical (208)	Simple and Axillary (10)		Excision of mass only (1)
		Simple (43)		
Excellent	78 (37 5%)	15 (34 88%)	1 (10%)	1 (100%)
Good	61 (29 33%)	21 (48 84%)	7 (70%)	
Fur	46 (22 11%)	4 (9 3%)	0	
Poor	23 (11 06%)	3 (6 98%)	2 (20%)	

TABLE VIII —Swelling of Arm (236 cases)

	Radical (230)	Simple & Axillary (9)		Excision of mass only (1)
		Simple (43)		
None	129 (56 05%)	38 (88 37%)	7 (77 78%)	1 (100%)
Slight	53 (23 04%)	1 (2 33%)	0	
Moderate	32 (13 92%)	3 (6 97%)	1 (11 11%)	
Severe	16 (6 99%)	1 (2 33%)	1 (11 11%)	

Table VI presents the cases grouped according to the pathologic diagnosis, and in the first column, divides them into the percentage of each diagnosis in the total of 414 cases. Next is presented the occurrence of axillary nodes as found by the pathologist. In the next group, is the type of operation performed in each different type of carcinoma, and in the next group, the five-year survivals, and the last group, the five-year survival without recurrence. Perhaps too much detail has been combined in this one table but the important figures are in the first and last groups, namely the five-year survival without recurrence in each type of carcinoma.

Chart IX presents graphically the types of operations performed with the five year survival rate and the survival without recurrence in each type of operation. Of the 90 simple mastectomies or simple mastectomy with axillary nodes removed, 76 were done as palliative procedures. This, of necessity, reduces the percentage of cases in the five-year cure groups. We feel that in some cases it is better to do a simple mastectomy than a radical. The patient should be treated as an individual. No routine management

TABLE IX—*Length of Hospital Stay (258 cases)*
(11 died in hospital and 148 are not recorded)

	Per Cent
1—5 days	5.52
6—10 days	41.09
11—14 days	21.36
15—21 days	19.14
22—30 days	5.18
Over 30 days	7.71

should be used in all cases. In patients who are 70 years of age or older, or in those whose general health would not justify a radical operation, or in cases of a known low grade malignancy in an older person, a simple mastectomy is recommended rather than a radical. The life expectancy in these patients is so much shorter than that of a younger patient and the added strain of the radical operation jeopardizes her welfare more than the possibility of having a recurrence of the tumor. This is a dangerous statement to make, for some might use it as an excuse for not doing the more radical operation. We feel, however, that in those cases surviving five years without recurrence, it is perhaps due to other causes than our efforts. The good results depend more upon the nature of the tumor and the resistance of that particular individual against tumors, than to any other factors. There have been cases which clinically appeared to be very malignant and which were reported by the pathologist as being quite cellular and likely to return both locally and at distant points, and who are living as long as 15 years. On the other hand, there was one patient who was considered as being inoperable, who had numerous nodules in the skin and the lesion in the breast was about to ulcerate. She was given a preoperative cycle of roentgen-

may treatments and told to return for her radical mastectomy. She failed to return, was seen again five years later still living, but, of course, with her cancer rather active. Had she been operated on, by either a radical or simple mastectomy, that operation probably would have been credited with giving the five-year cure. In the cases who died from the operation, many would have survived had they had a simple mastectomy rather than a radical one, particularly among the older age groups.

Table VII records the use of the arm at discharge and the eventual use of the arm and requires no comment. Table VIII records the post-operative use of the arm and the swelling of the arm. These require very few comments other than to state that there was a higher percentage of cases who had

First Recurrence (318 Cases)










Local	52		16.35%
Axillary node	26		8.18%
Infra or supra clavicular	50		15.73%
Other breast	9		2.83%
Bones	32		10.06%
Lungs	29		9.13%
No recurrence	113		35.54%
Cerebral	6		1.88%
Other places	1		0.31%

CHART XII—The site of recurrence

radical mastectomy and no swelling of the arm, than was anticipated. As a rule, a patient who is to have a radical mastectomy and a thorough axillary dissection will have some swelling of the arm. Table IX presents the length of the hospital stay and needs no comment other than to remind one that in dealing with clinic cases, they are more prone to “like” hospital life, and are also frequently kept for the convenience of the House staff.

Chart X represents the length of life after operation, both with and without recurrence. The five-year survival without recurrence of approximately 36% is somewhat lower than is given in most series, but is accounted for by the conditions which have been previously noted: the inclusion in this series of 76 cases who had nothing more than a palliative simple mastectomy, sometimes with the removal of some of the lower axillary nodes, and of many instances, in which the operation was performed in spite of distant metastases. A careful examination of this chart will give the percentage of survivals for each number of years postoperatively. There was only one patient, who has now lived for 20 years since her radical mastectomy, one is living 19 years after, and two, 18 years after.

Chart XI records the location of the tumor. As in our previous report, and in most other series, the vast majority of carcinomas occur in the upper outer quadrant. Of these, 86.2% were in the upper half of the breast. One of us (W.P.N.) has previously offered as an explanation for the occurrence of so many of the carcinomas in this location of the breast, and of the pre-existing mastitis, the fact that the breast is not properly supported when a woman assumes the upright posture. To help prevent this, we feel that a good brassiere is a necessity and will do much toward preventing cancer of the breast. Such a brassiere should have two straps in front, the lateral strap giving the support to that portion of the breast which is most frequently

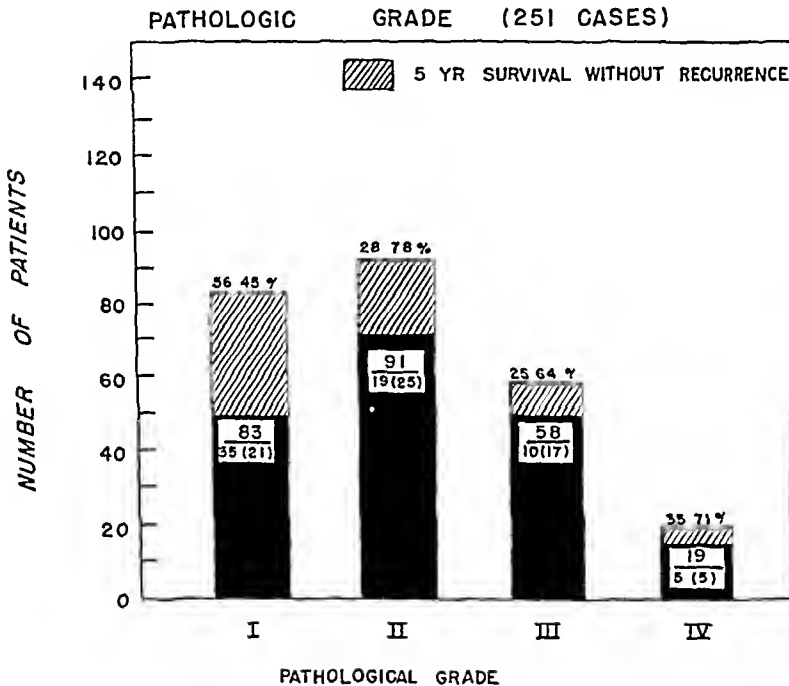


CHART XIII—Results grouped according to the pathological grading of the tumors

affected. Spencer, Inc. is cooperating in this effort and makes a very satisfactory brassiere individually designed and fitted.

Nine deaths occurred within one month of operation. This is a rather high percentage, namely 2.16%. The cause for death in these cases was in 3, a massive infection of the wound with general septicemia or purulent endocarditis. In 2 cases, consciousness was never regained. One of these, apparently had signs of a cerebral hemorrhage. The other had had only a palliative simple mastectomy and, in each case, they survived only three days. Two cases developed mesenteric thrombosis as proven at autopsy. One had diabetes and a generalized sepsis and died on the 22nd postoperative day, and another died on the 9th day from a coronary thrombosis. Only one of these was less than 50 years old and four were over 60.

No hormonal therapy had been used at Steiner before 1942. No estrogens nor androgens were administered to any case in this series. Surgical castration was not carried out in any case. In most instances, in the pre-menopausal era, radiation over the ovaries was recommended but was frequently refused, especially by the colored patients. Only 14 cases in the pre-menopausal period received radiation to the ovaries. Eleven of these were followed for five years and 90% or 10 of the 11, were not only surviving but had no evidence of disease at the end of five years. In seven of these nodes were noted clinically, and in three involved nodes were found by the pathologist. Of the other 162 cases in the pre-menopausal era who did not receive radiation to the ovaries, 39% (56 cases) survived five years and 34% (42 cases) survived for five years without recurrence. Of the 214 post-menopausal cases, 34% (53 cases) survived five years without recurrence. In such a small group as 14 cases, one can not draw conclusions but the striking difference between a 90% five year symptom free survival compared to less than 35% is certainly significant and would apparently indicate that a destruction of the ovaries, either by surgical removal or by radiation in a person in the pre-menopausal period is to be advised and most strongly recommended.

Chart XII records graphically the site of recurrence. Over 16% (52 cases) showed a local recurrence. As a general rule, an early local recurrence indicates that the surgeon did not go widely enough from the lesion, or that the patient was one who should not have been submitted to surgery. Of these 52 cases, 39 had received preoperative radiation, in six skin grafts had been used, and 49 had received postoperative roentgen-ray treatments. In 11 of these 52, a radical operation was not performed, in three supra-clavicular nodes were noted at time of operation, and in 21 the skin was ulcerated, fixed to the mass or showed orange-peel effect.

Chart XIII records graphically the results grouped according to the pathological grading of the tumors. It is remarkable to note a higher salvage rate in the grade IV lesions than in grades II and III. No explanation for this can be offered other than the relatively small number of cases in this group.

COMMENT

An analysis of the findings and results in 905 cases of cancer of the breast, of which 417 were treated surgically, has been presented. These have been grouped as to age, marital status, chief complaint, history of injury, history of discharge from the nipple, history of lump in the breast, duration of lump, number of pregnancies and lactations, menstrual abnormalities, size of lump, skin changes, involved axillary nodes, preoperative radiation, infection, use of skin grafts, wound healings, use of arm, swelling of arm, pathologic diagnosis, type of operation, location of tumor, radiation to ovaries, and the mortalities analysed.

CONCLUSIONS

No definite conclusions can be drawn from a study of such a series, but certain facts are strongly suggested

- 1 The relatively young patient isn't more hopeless than the older ones
- 2 Pain in the breast is rarely the presenting chief complaint
- 3 There was no history of familial cancer in over 75% of the cases
- 4 80% gave no history of injury to the breast
- 5 88% gave no history of a nipple discharge
- 6 93.5% gave a history of a lump in the breast, of which 25% had existed more than a year, and 14% more than two years only 11% were seen in less than a month after the lump was discovered
- 7 One third of the cases had had no pregnancy or lactation
- 8 Abnormal menstrual histories were noted in only 10% of the cases
- 9 The size of the lump apparently had a definite bearing on the result except in the small lumps (of which there were only 10), and those between four and five centimeters. No explanation is offered for the relatively better results in the latter group
- 10 No case which had either a retraction of the nipple, or an orange-peel skin, or a fungating tumor was salvaged for as long as five years. Best results were obtained in those cases showing no changes in the skin or a dimpling of the skin
- 11 Those cases who received no preoperative radiation showed about a 7% higher salvage rate
- 12 In carefully selected cases a simple mastectomy with removal of the lower axillary nodes is advocated rather than doing a more radical operation
- 13 The postoperative swelling of the arm is not noted in as many cases as previously supposed
- 14 Proper support of the breast by a good brassiere is probably a good prophylactic measure against so-called chronic cystic mastitis, and perhaps carcinoma
- 15 Destruction of the ovaries either surgically or by radiation in the younger women apparently definitely enhances their chances of survival
- 16 36% survived five years or more without recurrence and an additional 5% lived that long but had recurrences

Appreciation is expressed to the Georgia State Department of Health, and to Mr Garvin and Mr Ezelle in particular, for assistance in tabulating results and determining percentages

DISCUSSION—DR THOMAS C. DAVISON, Atlanta. Some time ago I reported a series of cases from the Georgia Baptist Hospital in Atlanta, and the Sheffield Cancer Clinic, in which I divided the cases into private patients and clinic patients. I found that in private patients there was a five-year survival of 50 per cent, and in the clinic patients there was a five-year survival of only 28 per cent. One would expect a difference, but I was surprised that it was so great. The private patients are more intelligent, seek treatment earlier and take advice more readily, while clinic patients neglect themselves and are not inclined to take advice when given.

I would like to put in a plea for the derelict breast cases with metastases, both bony and soft tissue metastases, following operation. Recently at the Sheffield Clinic we have been using the male sex hormone, testosterone, to treat these apparently hopeless cases. We have a series under treatment now, and in certain instances have had almost startling results. Two cases who came in on crutches, after having been given 50 mg of testosterone daily for several doses, threw away their crutches, while two others who were taking morphine for pain, voluntarily stopped its use, others gained weight, felt much better and improved in every way. In some cases with bony metastases the x-ray showed recalcification, while still others died in spite of treatment. This remedy is not a cure and its use is still in the experimental stage. We are not claiming anything in the way of a cure but simply give you the facts for what they are worth. Its use in these patients has been likened to a person jumping out of a plane without a parachute as compared to one with a parachute — it lets them down easy. There is one objection to this treatment, some of the women sprout a mustache and develop a hoarse voice.

DR EDGAR D GRADY, Atlanta. Recent developments in the treatment of cancer of the breast by hormonal therapy make it appropriate to re-emphasize the facts brought to light in this review, showing the possible relationship of sex hormones in the genesis and regulation of breast cancer. It has been shown experimentally that oophorectomy in strain C-314 mice reduced materially the incidence of cancer of the breast. In a similar strain of mice which had a high susceptibility to cancer of the breast, administration of androgens has decreased the incidence of spontaneous breast cancer.

We found that the greatest number of cases of cancer of the breast appeared near the menopausal age, 246 cases were between the ages of 41 and 60, while there were 90 cases in the age group of 40 years and under, 81 were in the age group of 60 years or more. Carcinoma of the breast thus appears to be most frequently a disease of the involuting breast, a breast in which the hormonal influence has recently been changed.

Of the 10 per cent of our cases who had abnormal menstrual histories, only 16.3 per cent survived five years without recurrence, compared with 39 per cent survival without disease in the cases who had normal menstrual histories. The abnormality of menstrual history demonstrates the disturbance in the patient's production or regulation of her sex hormones. The response of menstruation to hormonal stimulation was unusual, and her breast cancer was also unusual.

In the 11 pre-menopausal patients who received radiation castration and who were followed for five years, 10 of the 11 had no evidence of disease at the end of that five-year period.

We feel, then, that breast cancer is an endocrine problem as well as a surgical and radiologic problem. It is our aim to give greater hope to the woman with breast cancer through early diagnosis, improved therapeutic measures and improved palliative therapy.

DR ISIDORE COHN, New Orleans (closing). Since Dr Nicholson has emphasized that their patients are getting pre-operative radiation, I want to make it clear that we have not used, so far as I know, preoperative radiation. I know this has been done in none of my cases. These patients who come in on an average of a year and a half after symptoms I waste no more time on, it has been long enough already.

When we say 62 per cent had lymph nodes in the axilla, I meant that they were palpable. Recently I operated on a patient in whom I could palpate no lymph nodes, but the pathologist found carcinoma cells in three out of 24 small lymph nodes.

I have had less trouble since using the transverse incision (Stewart) in the last thirty years, so far as arm movement is concerned.

* Dr Cohn's paper "Further Study of Carcinoma of the Breast in the Negro" will appear in the Southern Surgical Transactions, Vol 59, 1947.

RATIONALE AND RESULTS IN RETROPUBIC PROSTATECTOMY*

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THREE METHODS OF REMOVAL of the prostate gland have been recognized up to recent months. No one of these has been wholly satisfactory, and each has been characterized by several very unfavorable features. It is in no wise the purpose of this paper to enter into a controversy of the relative merits of these three methods, but in order correctly to determine the value of Retropubic Prostatectomy it is necessary briefly to review the shortcomings of the three standard types.

The suprapubic operation has the highest mortality, it requires passage through the bladder mucosa twice in order to reach a gland which, in truth, lies entirely outside the bladder. The enucleation of the gland is done blindly, and it necessitates rubber bags and packs to control the hemorrhage. In addition, it offers no possibility of removal of a carcinomatous gland which has invaded the capsule.

Transurethral resection seems to us a procedure well adapted to small glands and median bars and for purely palliative treatment in the inoperable obstruction of carcinoma. Faith in its further extension however is maintained by some excellent urologists, but since the first fanfare of its introduction it has lost many of its hardy enthusiasts. Likewise, its mortality in large glands is very high except in the hands of very excellent resectionists. Its morbidity is prolonged by the necrosing of tissue electrically treated, stricture of the urethra is a frequent sequela and an enormous percentage of resections have to be repeated later or the glands removed by surgical methods because of remaining or recurring adenomata. Like suprapubic prostatectomy, the resection is unsuccessful in the radical removal of prostatic carcinoma and is far more likely to leave intracapsular malignancy than even suprapubic enucleation.

Perineal prostatectomy is truly a surgical operation, the gland being enucleated under direct vision, hemorrhage being completely controlled by suture. It has the lowest mortality of the three recognized methods when large glands are removed. It also possesses a great advantage in that it is readily applicable to removal of the malignant prostate which has involved the capsule. The postoperative morbidity is low and the patients have a minimum of surgical shock. However, it has its serious drawbacks as well. The position on the operating table is a definite strain on the patient, it requires trained surgical skill and a thorough knowledge of perineal anatomy, a cooperatively trained team and considerable special equipment. Even in skilled hands there is frequently some temporary incontinence from a few days to a month or two, and in inexperienced hands the results are terrible, persistent fistula, injury to the rectum and complete incontinence being very

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Wednesday, December 10, 1947

frequent sequelae In a great majority of patients sexual potency is lost or much impaired

The operation of Retiopubic Prostatectomy as devised and described by Mr Terence Millin, a famous urologist in London, has a completely new approach The space of Retzius has been anathema to urologic surgeons since the beginning of suprapubic procedures on the bladder, and indeed at least six different methods have been devised by advocates of suprapubic prostatectomy to seal off or occlude this space of historical potential danger when operating Nevertheless it is directly through this space that the new approach to the prostate has been made, and apparently the stone rejected of the builders has become the chief cornerstone

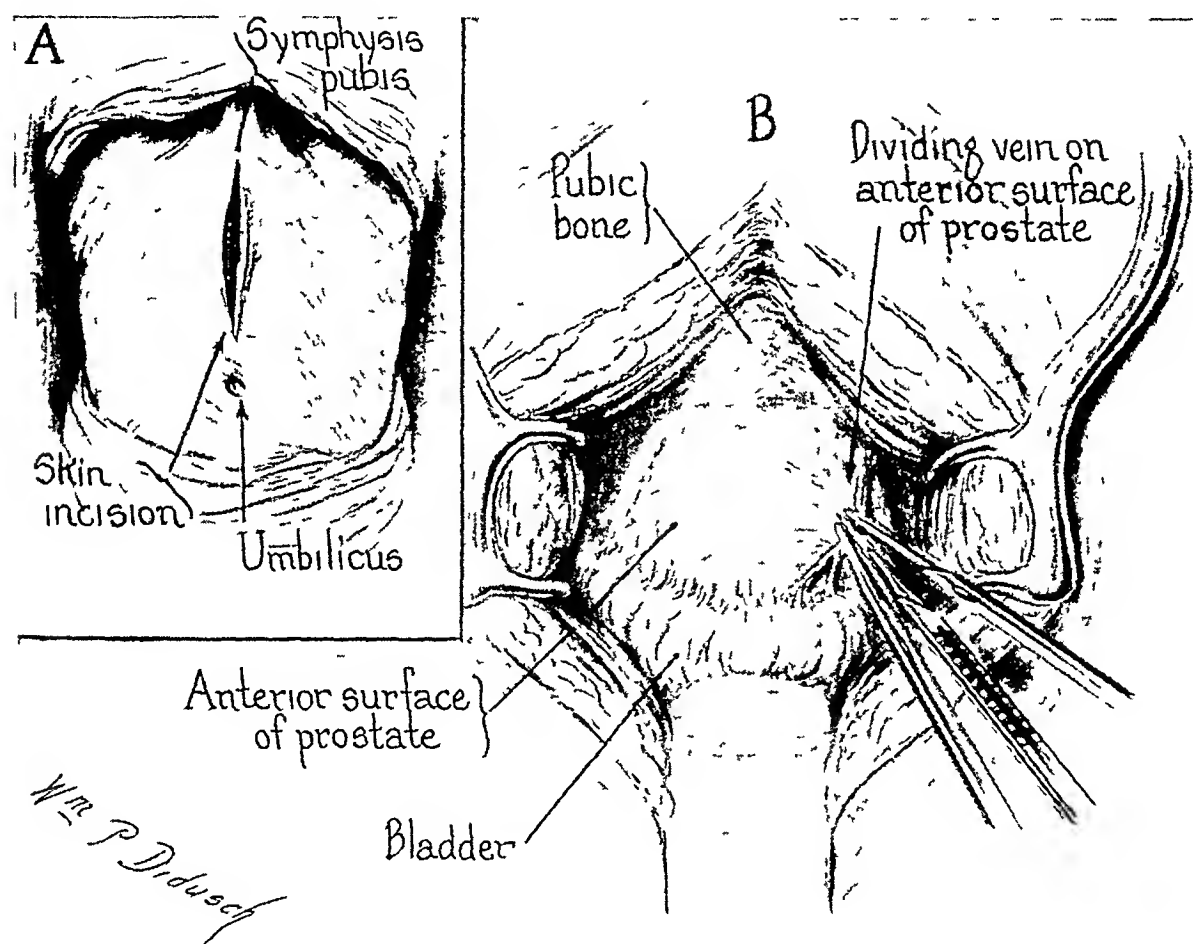


FIG 1 — (A) Skin incision
(B) Exposure of vessels in adipose tissue covering the prostatic capsule

The technic of the procedure is shown in Figures 1 to 5 The skin incision may be vertical or transverse, at the present time we prefer the transverse for better healing The skin and subcutaneous fat are incised to the rectus sheath which is then likewise cut transversely and the recti muscles separated The insertion of a two-blade retractor then thoroughly exposes the field In the wound can be seen the space beneath the pubic arch, the preprostatic layer of fat which ordinarily occupies the space of Retzius and the vessels

coursing through this fat. A third blade of the retractor is then introduced to push back the previously emptied bladder. Then on each side of the prostate, now covered with the fat and tissue containing the vessels, a gauze pack is introduced well under the pubic arch region and practically up to the posterior layer of the triangular ligament. These two packs are to isolate the prostate and more accurately to define its extent. The vessels in the tissue over the prostate are then ligated with sutures. They consist usually of two or three distinct branches and can be readily seen. The sutures ligating these vessels should be carried deeply by the needle even to entering the capsule. A pair of curved long blade Mayo scissors are introduced into this incision and the prostatic adenoma loosened from its bed and the

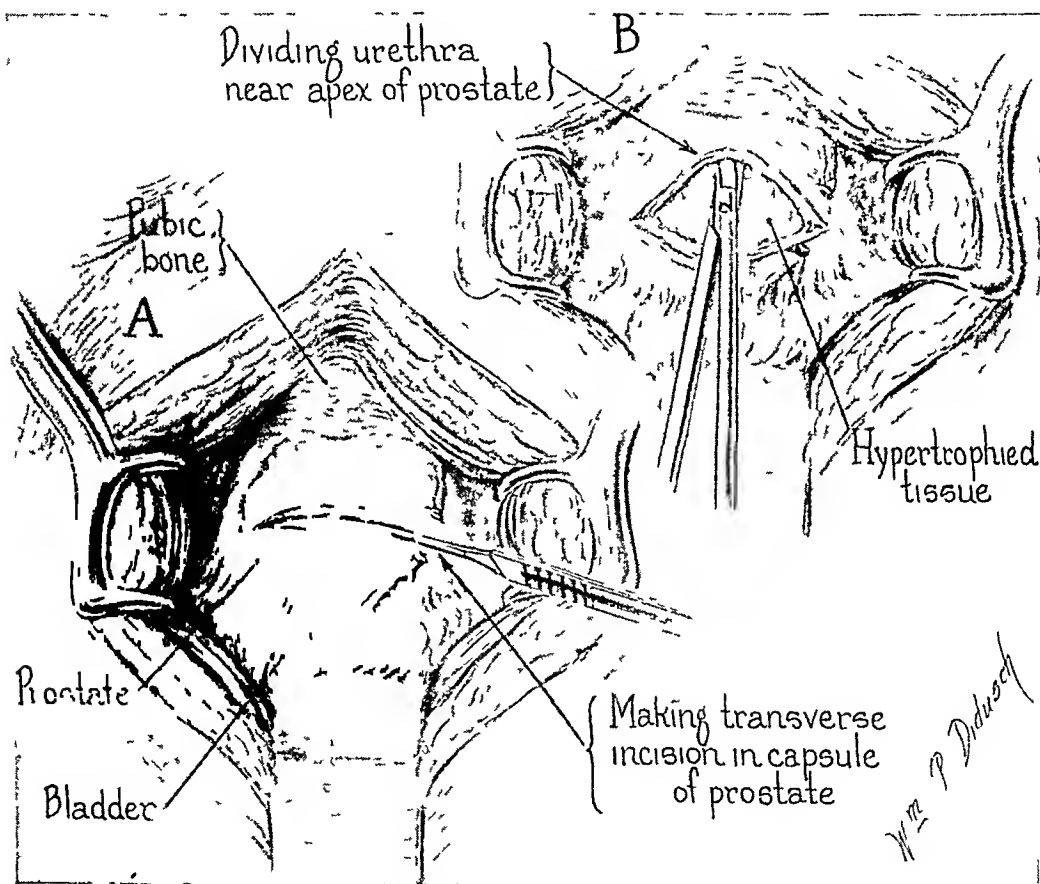


FIG 2—(A) Incision in the capsule between the ligated vessels
(B) Division of the urethra at the apex within the prostatic capsule

urethra cut across near the prostatic apex. The gland is then enucleated, beginning at the apex *toward* the bladder. This is done either with the finger or with the blunt scissors. When the enucleation has reached the vesical neck, the gland is lifted well into the wound and separated from the bladder by blunt dissection. As the gland is peeled off the bladder the prostatic

arteries, which usually are located at the lower sides of the vesical neck, can frequently be seen and caught by clamps even before the gland is completely freed. The enucleation is then finished, and if the prostatic arteries have not been already caught, they are readily seen and are ligated with a figure of eight sutures which extends into the base of the capsule. We consider this step extremely important and to it attribute our minimal loss of blood at operation and the clear urine postoperatively. In our early cases we did not secure these vessels so carefully and definitely determined that the one case of postoperative bleeding came from this area. The lateral packs are now removed.

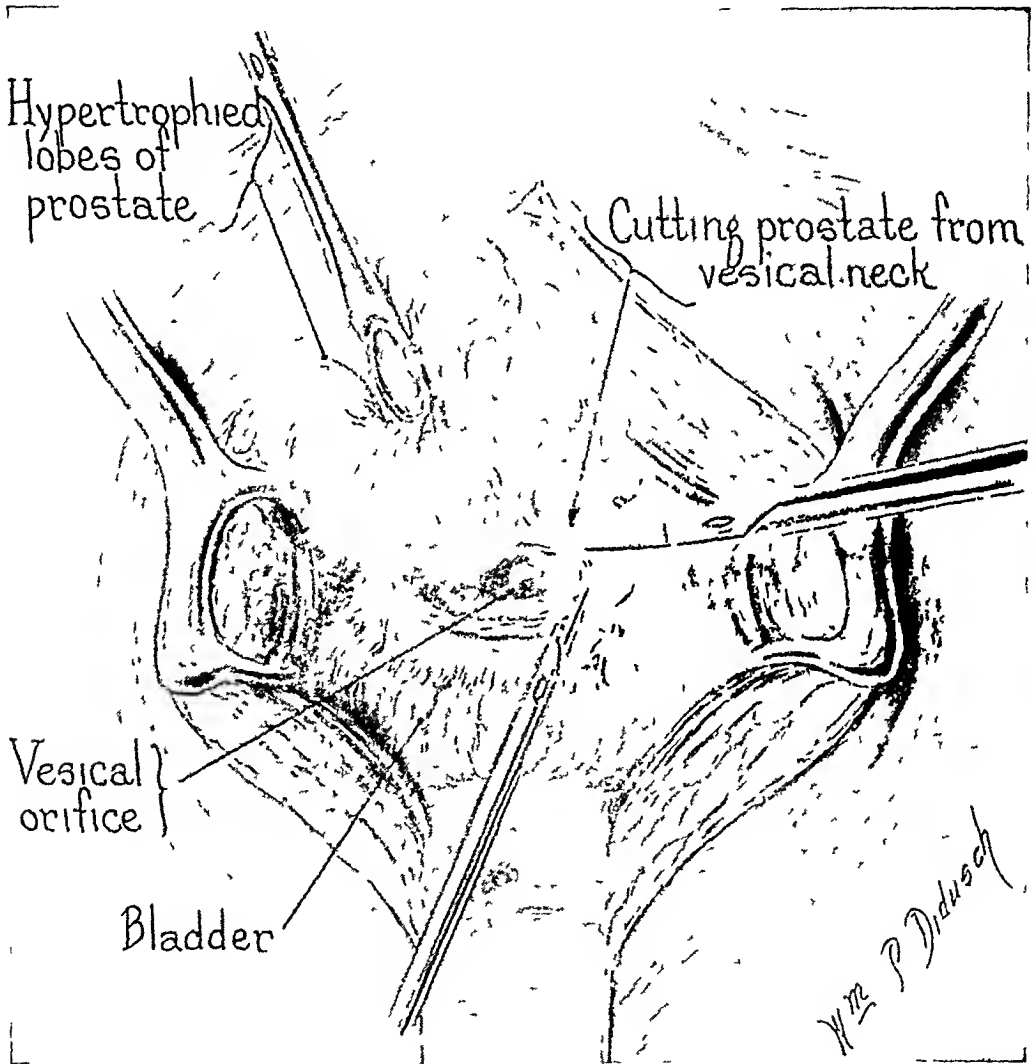


FIG 3—The enucleated gland delivered being trimmed from the vesical neck

The bladder is digitally examined for calculi or diverticula. Five of our cases were complicated by vesical calculi, in two cases large multiple ones which were readily removed through the vesical neck by means of forceps. With the exception of dilating the mouth of diverticula, we have done nothing toward correcting this condition but it is well to recognize the presence of diverticula, since they may cause some amount of residual urine postoperatively. Of three cases with diverticula two required considerable lavage postoperatively before they cleared.

The bed from which the gland has been enucleated is inspected under direct vision for any stray nodules or tags. If the gland has been neatly and completely removed, the prostatic bed is dry. A catheter is then introduced from the meatus and passed into the bladder. This is then gently irrigated to wash out any clot or detritus. The cut surfaces of the capsule are drawn together with sutures passing well into each side. We now use continuous

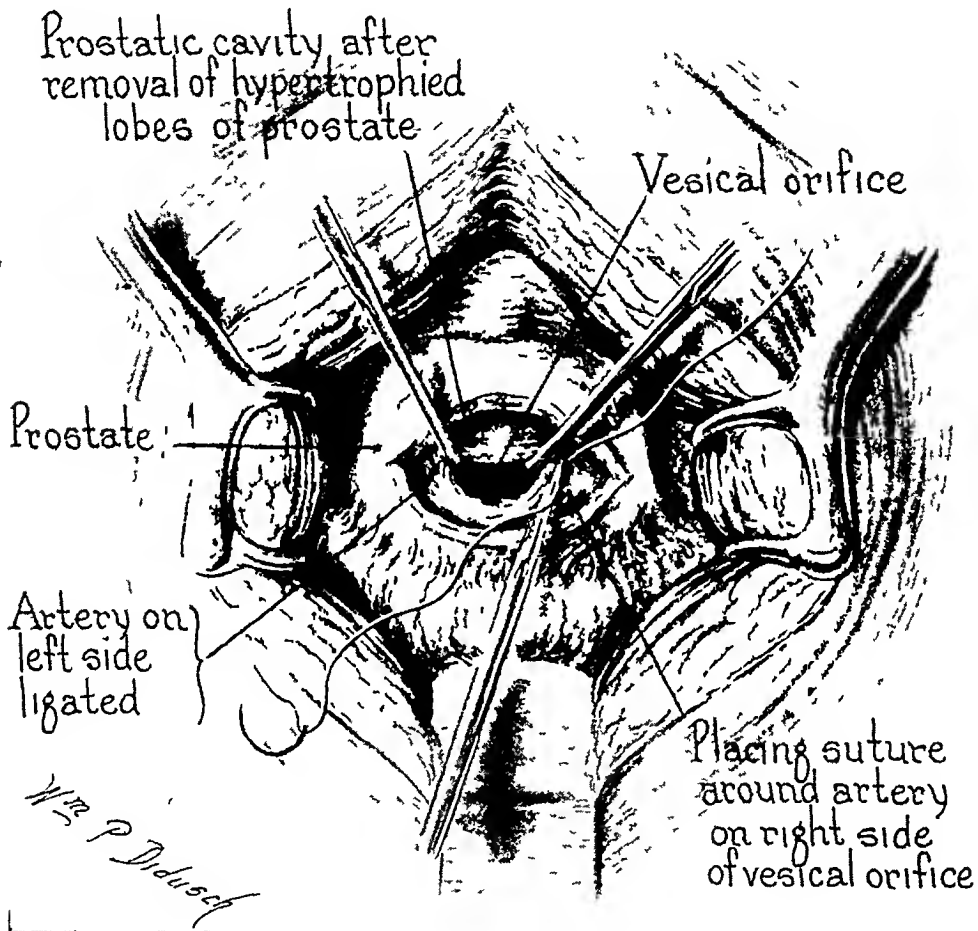


FIG 4—Ligation of the prostatic arteries

sutures for this purpose. The wound should be perfectly dry. It is important to carry these capsular sutures well into the angles, since it is usually at this point vessels may be present that were not caught in the sutures taken prior to incision of the capsule. A small piece of rubber tissue is introduced to the suture line in the prostatic capsule to care for any serious seepage and the wound closed completely about this tissue drain. The drain is removed usually on the second or third day.

RETROPUBIC PROSTATECTOMY

In performing radical prostatectomy retropubically, the steps are the same up to the point of incision in the capsule. After the veins have been ligated the fatty tissue is retracted and the puboprostatic ligaments come readily into view. These are severed and the prostate at its apex is quite free. The apex is cut across at the triangular ligament and turned toward the bladder with the capsule intact. This readily separates from the rectum and

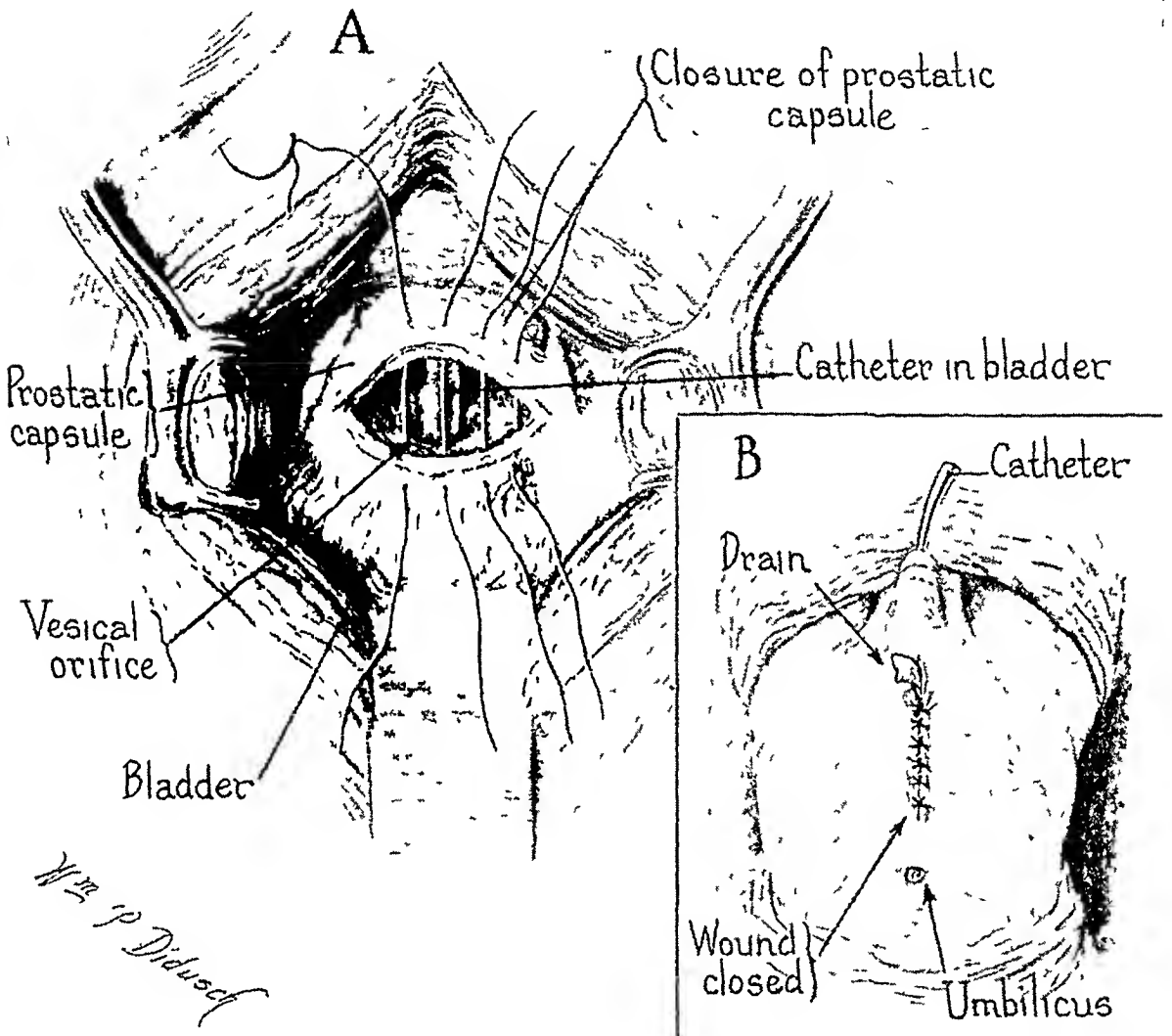


FIG 5—(A) Closure of prostatic capsule over a retention catheter
(B) Skin closure with cigarette drain

the seminal vesicles are clamped and removed with the intact prostate if desired. It is wise to remove vesicles in carcinoma perhaps, but in the fibrous prostate, especially those with calculi which are removed with the capsule intact, extirpation of the vesicles is not necessary. The gland is then cut free from the bladder neck and the bladder neck anastomosed to the distal urethra. We found that when the pubo-prostatic ligaments are cut the length of the distal urethra is fully sufficient for anastomosis to the bladder neck.

Our series is too brief, fifty cases, and the time elapsed 5 months, too short for final judgment, but to date we have been so pleased in every respect

TABLE I—*Detailed Analysis of 50 Cases of Retropubic Prostatectomy*

Date			Patient	Type Prostate	Drainage Period	Catheter Period	Pathologic Findings	Complica- tions	Post Opera- tive Stay	Age	Remarks
Mo	Day	Yr									
5	3	47	CB	Trilobe ++	4 Days	6 Days	Benign	None	10 Days	65	
6	26	47	EK	2 Lateral	4 Days	4 Days	Benign	None	11 Days	69	
7	5	47	JN	Trilobe ++	14 Days	14 Days	Benign	None	20 Days	65	Prostatic calculi, large vesical diverticulum
7	5	47	JB	Trilobe ++	4 Days	6 Days	Benign	None	12 Days	74	A marked phimosis
7	12	47	JF	Fibrotic	4 Days	6 Days	Benign	None	10 Days	72	Prostatic stone
7	15	47	WCC	Trilobe ++	14 Days	8 Days	Benign	None	30 Days	76	Suprapubic drainage 5 mos, pre- liminary Grave kidney defici- ency Recovery complete
7	16	47	JH	Trilobe ++	3 Days	6 Days	Benign	Cerebral acci- dent	10 Days	75	Cerebral accident, 2nd post-oper- ative day
7	19	47	CS	Trilobe	3 Days	6 Days	Benign	None	15 Days	64	
7	22	47	MR	Trilobe	4 Days	6 Days	Benign	Calculus	13 Days	80	Calculus vesical 5 x 5 x 3 cm
7	25	47	AG	2 Lateral	17 Days	17 Days	Benign	Diabetic	22 Days	74	Long drainage, probably occa- sioned by diabetes
7	26	47	JE	Bilobe	3 Days	6 Days	Benign	None	14 Days	78	
7	29	47	JB	Trilobe ++	4 Days	5 Days	Benign	None	13 Days	76	Vesical calculus, 2 1/2 x 1 x 2 1/2 cm
7	29	47	HV	Bilobe ++	10 Days	10 Days	Benign	Bleeding	28 Days	73	Re-opened and drained wound
8	5	47	CB	Bilobe	2 Days	6 Days	Benign	None	9 Days	76	Vesical calculus
8	6	47	IH	Trilobe	4 Days	7 Days	Benign	None	10 Days	67	
8	7	47	MC	Trilobe	3 Days	7 Days	Benign	None	9 Days	67	
8	16	47	NG	Trilobe	1 Day	5 Days	Benign	None	8 Days	62	Three stones, 2 x 2 x 2 cm
8	30	47	LF	Trilobe	3 Days	6 Days	Benign	None	8 Days	67	None
8	30	47	SS	Trilobe ++	4 Days	7 Days	Benign	Large diver- ticulum, oc- casioned leakage	14 Days	71	

RETROPUBIC PROSTATECTOMY

TABLE I — (Continued)

Date			Patient	Type Prostate	Drainage Period	Catheter Period	Pathologic Findings	Complicat- ions	Post Oper- ative Stay	Age	Remarks
Mo	Day	Yr									
9	3	47	G H	Small Median Lateral	3 Days	7 Days	Benign	Hypopro- teinemia	15 Days	77	Hospital stay prolonged on ac- count of delayed wound healing
9	5	47	R C	Trilobe	2 Days	5 Days	Benign	None	10 Days	60	
9	6	47	J P R	Trilobe	2 Days	6 Days	Benign	None	8 Days	64	
9	9	47	A A	Fibrotic	3 Days	10 Days	Benign	None	12 Days	57	Radical prostatectomy, removing capsule
9	9	47	C S	Trilobe +++	2 Days	8 Days	Benign	None			
9	17	47	F D	Trilobe	3 Days	7 Days	Benign	Secondary hemorrhage	11 Days	67	Secondary hemorrhage, twice
9	18	47	C P	Bilobe	2 Days	5 Days	Benign	Hemorrhage	12 Days	58	Secondary hemorrhage, 7th post- operative day
9	18	47	M T	Trilobe	2 Days	5 Days	Benign	Hemorrhage	15 Days	74	Secondary hemorrhage, day of operation
10	9	47	S R	Trilobe	2 Days	5 Days	Adeno car- cinoma	None	11 Days	67	Adenocarcinoma, Grade I to II
10	9	47	E D M	Trilobe	3 Days	6 Days	Benign	None	14 Days	65	
10	11	47	W G D	Bilobe	2 Days	6 Days	Benign	None	11 Days	62	
10	11	47	F N D	Bilobe	2 Days	7 Days	Benign	None	6 Days	63	
10	16	47	D G	Trilobe	1 Day	4 Days	Benign	None	6 Days	59	
10	23	47	L T	Trilobe	2 Days	5 Days	Benign	None	8 Days	62	
10	25	47	L B	Bilobe	2 Days	5 Days	Sarcoma	None	6 Days	71	Thrombophlebitis
10	28	47	H G	Trilobe	2 Days	8 Days	Benign	None	25 Days	63	
11	10	47	A R	Bilobe	2 Days	2 Days	Benign	None	10 Days	65	
11	11	47	A G	Bilobe	1 Day	3 Days	Benign	None	7 Days	67	
11	11	47	W S	Bilobe	1 Day	3 Days	Benign	None	8 Days	74	
11	15	47	G M	Trilobe	1 Day	3 Days	Benign	None	16 Days	82	
11	15	47	T R C	Trilobe	1 Day	4 Days	Adeno- Carcinoma	None	10 Days	58	Adenocarcinoma, Grade I to II
11	20	47	J C	Bilobe	2 Days	3 Days	Benign	None	11 Days	83	

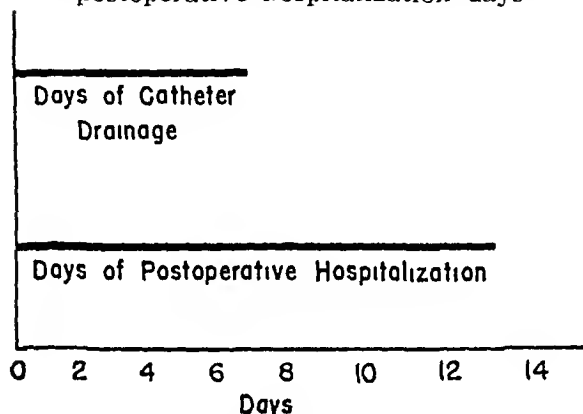
TABLE I — (Continued)

Date			Patient	Type Prostate	Drainage Period	Catheter Period	Pathologic Findings	Complica- tions	Post Opera- tive Stay	Age	Remarks
Mo	Day	Yr									
11	22	47	S M	Trilobe	3 Days	4 Days	Benign	None	10 Days	75	Bilateral orchiectomy
9	17	47	W J	Large lateral	3 Days	6 Days	Adeno- carcinoma	None	11 Days	73	
9	22	47	T M	Trilobe	5 Days	7 Days	Benign	None	9 Days	65	Prolonged stay due to abscess space Retzius Recovered promptly
10	13	47	F S	Trilobe	3 Days	6 Days	Benign	None	12 Days	68	
10	27	47	A S	Trilobe	4 Days	12 Days	Benign	None	17 Days	57	
10	27	47	W T	Median	4 Days	12 Days	Benign	Infection space of Retzius	23 Days	65	
				Moderate							
11	10	47	V M	Lateral	3 Days	4 Days	Benign	None	10 Days	65	
11	17	47	S	Trilobe	2 Days	3 Days	Benign	None	9 Days	72	
11	24	47	J M	Small med bi	2 Days	3 Days	Benign	None	5 Days	71	

that we feel quite justified in calling this operation to your attention. It is in truth performed like a perineal prostatectomy upside down, having all the advantages of that procedure including ability to remove the prostatic capsule and vesicles radically when desired, without the possibility of perineal injury and the disturbance of the pelvic floor which at times occasions incontinence and sexual impotency.

Table I shows the morbidity and complications encountered. It will be seen that we met with diabetes five times, stone in the bladder four times, diverticula three times, and two radical operations were done for predetermined carcinoma. In our 50 cases we have had no mortality which, in these days of surgically performed prostatectomy is not unusual, but we have had

TABLE II
Summation of catheter drainage days and
postoperative hospitalization days



no single fistula, no single case of incontinence which is better than our experience with any similar number of cases performed in any other manner. We have not made a complete survey of sexual potency but we have had no voluntary complaint and in 25 cases that we have questioned none have commented upon any alteration in the sexual powers from that prior to operation. With the precise control of bleeding

the loss of blood is so minimal that transfusion to replace volume is not necessary. One of our earlier cases bled because we had not secured the prostatic artery, but this was controlled as soon as recognized.

In addition to our own personal satisfaction with these cases, we can add that both our patients and our nurses who are astounded by the smooth postoperative course. Most patients are up the second day, postoperative, voiding without a catheter by the fifth or sixth day and ready to leave the hospital by the eighth day (Table II). We are not prone to release a prostatectomy patient from the hospital too early, but since we have had no single case of epididymitis, one phlebitis and no serious infection, we are now dismissing most of them on the twelfth day.

No surgical method that we know of is faultless, and the removal of a diseased prostate is as little likely to present perfect results in every case as any type of surgery. Our advocacy of this method is not based on any pride of discovery or invention because indeed we theoretically criticized Mr. Millin's articles with him over a year ago and undertook the operation with little conviction of its success. Certainly at the present time we are enthusiastic disciples of his. Fanaticism for any one method of prostatectomy has been a great drawback to surgical urology for at least three decades. Every surgical urologist should be able to perform all types of prostatectomy. Only after having done many of each is he at all qualified to judge their merits.

because unquestionably there is a place for each type. We have felt that no other series of fifty cases of any other type have yielded consistent results comparable to those of the retropubic route. Sufficient data and number of these cases have not been collected in this country to warrant our prophesying this procedure as the apotheosis of prostatectomy but at least we feel that if it is not the best it is better than the rest.

Since the submission of this paper for publication, we have added 45 cases of retropubic prostatectomy to the series with the same continued satisfactory results.

DISCUSSION—**DR. HAMILTON W. MCKAY**, Charlotte, N. C. Doctor Grant has said that the urologists have three standard operations and, when indicated, any one of the three gives excellent results in skilled hands. The operation described by him and advocated by Millin of London gives urologists a new approach to the prostate which offers many possibilities.

I am especially interested in diagnosis of and radical operation for early carcinoma of the prostate which will not produce temporary incontinence, and I believe that the retropubic approach to the prostate would be ideal for a radical operation. We know that in a radical perineal prostatectomy for carcinoma where the bladder is anastomosed to the urethra, patients do get temporary incontinence from a few weeks up to three months. In my opinion there is no complication which gives a patient so much concern or the urologist so much trouble as dribbling of urine.

Few of us have had an opportunity to master the technic of this operation. I am fully aware that the operation is not without complications, for such complications as osteomyelitis of the pubic bones, hemorrhage and others have already been reported, but I do believe that all urologists interested in prostatic surgery should master the technic of this operation as soon as possible.

I personally want to thank Doctors Grant and Lich for this presentation, and I am sure it will be a splendid contribution to surgical literature.

DR. HENRY L. DOUGLASS, Nashville, Tenn. I said that I was not going to discuss this paper, but I do want to ask some questions.

The first question is on the approach. For many years, as Doctor Grant pointed out, the space of Retzius was tabu. How well can the prostatic capsule be exposed through the retropubic space, and does this approach facilitate exposure and shorten the operation as compared to the transvesical route? I can see the advantages (1) of not opening the bladder and thereby avoiding prolonged drainage of urine through the wound and, (2) the avoidance of shock by better hemostasis which apparently the retropubic route permits.

Does postoperative catheter drainage adequately protect against leakage of urine into the retropubic space? If such leakage should occur, are the consequences as severe as we have in the past believed them to be?

Doctor Grant's experience with 50 cases indicates that retropubic prostatectomy has many advantages and little postoperative morbidity. It appears to be a great improvement in the treatment of prostatism, and I wish to thank Doctor Grant for bringing the operation to our attention.

MR. GUY BLACKBURN, Guy's Hospital, London, England. I should like to congratulate Doctor Grant on the series of cases he has discussed and, from my own experiences of a few cases, to add one or two points. The first is to suggest that a vertical incision is best in a thin patient for a one-stage operation, but a transverse incision may be preferable when the operation is done in two stages. Millin in fact does this. With regard to the bladder neck, some of the early cases developed strictures, requiring subsequent perurethral resection, and Millin's practice now is to cut out a V-shaped piece of bladder just above the internal meatus to avoid it.

I believe, in fact, that the Millin operation has made retropubic prostatectomy safe.

for the general surgeon, provided he has special instruments, adequate light, good suction, and a diathermy apparatus. The time of operation obviously varies in different hands, but the experienced will often complete it in approximately half an hour.

DR EDGAR BURNS, New Orleans. I would like to ask Doctor Grant a few questions based primarily on what has been the experience of some of the other American operators. First, the amount of hemorrhage lost during the operation, second, whether or not he has had any late postoperative hemorrhage as reported by a number of operators, third, whether or not any obstruction has occurred during the first few weeks or as late as two or three months, fourth, has he had any cases of osteitis pubis, which has also been reported by some of the Americans.

I do not think we can anticipate that the retropubic approach will be applicable to all cases of prostatic obstruction any more than any other method is applicable to all types. Contracture of the vesicle neck and prostatic bars can be removed easily by transurethral resection and probably should continue to be treated by that method. Perhaps 95 per cent of obstructions due to primary carcinoma of the prostate have infiltrated the periprostatic region by the time symptoms occur and do not lend themselves well to any type of open operation. On the other hand, transurethral resection for this type is ideal and will probably remain the method of choice until some non-operative cure for cancer is available. For the early carcinoma still confined to the capsule, the retropubic operation appears to offer distinct possibilities. I do not believe, however, that Doctor Grant or any other operator, including Mr. Millin, has had enough experience with this approach to early carcinoma to properly evaluate it at this time. Whatever one's approach to the benign lesions of the bladder neck may be, a good functional result is an iron-clad requirement, the morbidity should be minimal and the mortality, even on a teaching service where a large number of the operations are done by the residents, should be less than 5 per cent. We run a teaching service and expect to add the retropubic approach to the other methods already in use. Further experience may prove that the retropubic operation is better for the large benign hypertrophies and early carcinomas.

DR OWSLEY GRANT, Louisville, Ky. (closing). We feel that retropubic prostatectomy is an added implement to the armamentarium of prostatic surgery that does things other operations will not do. We are persuaded that incontinence, temporary or not, is not due to the fact that the sphincter is injured, but to the disturbance of the pelvic floor, and this is obviated by this procedure. The removal of a wedge from the base of the bladder neck we have felt unnecessary, since we have used meticulous care to suture the bladder neck when we tie the prostatic vessels. The bladder neck suture includes a bit of capsular tissue and this fixes the neck. As to capsular involvement in prostatic carcinoma, we know some cases which at first appeared inoperable have been reduced to operable cases by the use of estrogens. No operation which is incompetent to remove the prostatic capsule can ever be considered as the sufficient operation for all types of prostatic obstruction.

Our average blood loss by hemorrhage at operation is two ounces or less. Postoperatively, the urine is pink-tinged for about eight hours and then remains entirely clear. The usual blood loss is quite negligible due to very careful suturing. We had one postoperative hemorrhage in the early cases. We employ no hemostatic tissue or solution.

No special instruments are necessary but a good boomerang needle is helpful.

The time is less than for perineal prostatectomy because exposure is so much more readily accomplished and closure is easier, since reconstruction of the pelvic floor is not required. The average time is about forty minutes.

I should not want you to think that this is a two-stage operation, as someone has mentioned a two-stage type. It is, however, equally and satisfactorily applicable if, for unusual reasons, it has been deemed advisable to drain the bladder at a preliminary operation.

So far, in our hands, retropubic prostatectomy will do anything that any other surgical prostatectomy will do, and with less morbidity or uncomfortable sequelae.

CURRENT TRENDS IN SURGERY OF THE DISTAL COLON AND RECTUM FOR CANCER*

A STEPHENS GRAHAM, M D , M S
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CHOICE OF OPERATIVE PROCEDURE in cancer of the distal colon and rectum continues to hinge upon the acceptance or non-acceptance of colostomy, either temporary or permanent, as an integral part of the procedure. This has been a debatable subject since 1839 when Amussat¹ wrote in the defense of colostomy. By 1938—when I last made a complete survey² of opinion in this field—most English speaking surgeons had accepted the proposition that abdominal colostomy is an essential adjunct to a proper extirpation of the rectum and rectosigmoid. Moreover, they undertook in most instances a multiple stage resection of the distal colon, such as the Rankin obstructive resection. This near unanimity of opinion developed only after many years of painstaking ground-work by such stalwart pioneers as Miles and Lockhart-Mummery and subsequent demonstration by an overwhelming array of statistical data² of the soundness of their principles by Grey Turner, Gordon-Watson, Abel and Gabriel in England, Wilkie and Fraser in Scotland, Graham of Toronto, and in this country, Daniel Fiske Jones, Mayo, Cheever, Rankin, Stone, T. E. Jones, Pemberton, David, Pfeiffer, Lahey, Brindley, Collier and a few others. Almost alone among general surgeons of wide experience in surgery of the large bowel at this time was Babcock,³ who since 1932 had consistently condemned any procedure which required abdominal anus.

The tide of opinion, influenced by several factors, began to turn by the end of the last decade. Those surgeons who are unable to become reconciled to a colostomy life for their patients were prodded to unusual activity by the stimulus of the pathologic researches of Gabriel, Dukes and Bussey (1935),⁴ Gilchrist and David (1938),⁵ and Collier and his coworkers (1940)⁶ in which it was determined that the inferior zone of spread of malignancy through the lymphatic channels in cancer of the rectosigmoid and rectum was relatively meager. Commenting on the findings of Dukes, Lynch in 1938⁷ expressed an opinion in which many other surgeons were soon to concur. "It permits," stated Lynch, "one to discard entirely such radical and unnecessary operations as that popularized by Miles."

Another factor has been the tremendous gain in popularity of surgery of the large bowel as compared with a decade ago when relatively few undertook all the surgery in this field. Now almost every young general surgeon and an increasingly greater number of proctologists, on completion of their residencies, consider themselves fully qualified to perform this type of surgery. The necessity of re-exploration of the question of colostomy has been

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Thursday, December 11, 1947

recognized both by this new generation and also by a considerable number of the older general surgeons and proctologists whose interest in resections of the colon and rectum for cancer was late in developing.

Many of us who served in the Armed Forces returned to civilian practice completely confused by the tangled web of endeavor in this field. It was difficult to determine the true status of treatment for carcinoma of colon and rectum. A few surgeons had published articles unequivocally accepting sphincter-saving operations as the procedure of choice. Others, notably Wangenstein,⁵ were less positive as to the ultimate merits but were, nevertheless, favorable to these measures, primarily it would seem because of a decided personal aversion to colostomy. Few who were pre-eminent in this field had recently published their opinions.

In order to clarify this situation, preliminary to revision of our monograph² on cancer of the large intestine, Dr. Rankin and I sent questionnaires to surgeons in this country, Canada and Great Britain. In addition to questions dealing with the choice of operation for cancer of the distal colon, rectosigmoid and rectum, inquiries were made concerning the employment of complementary proximal drainage and chemotherapy. An inquiry of this nature would presumably be of greater significance if restricted to an analysis of the views of surgeons with relatively large and prolonged experience in the treatment of cancer of the large intestine. Where differences of opinion among colleagues in a few of the large institutions existed, their separate views have been recorded. On the other hand, in many instances opinions of qualified colleagues were identical, in which circumstance only the conclusions reached by the group were tabulated. Actually, therefore, the 50 expressions of opinion analyzed in this survey are representative of a somewhat larger number of individual surgeons. The department of surgery of 31 medical schools and seven clinics are represented.

It occurred to me that the value of this survey would be enhanced if the opinions of a few surgeons, generally considered leaders in this field, were contrasted with those of the remainder of the group. Accordingly, ten were selected whose pre-eminence few would question. Each has had a large experience which has extended over a period of more than 15 years. The results of this survey will be considered question by question.

IN APPROXIMATELY WHAT PERCENTAGE OF CASES OF CANCER OF THE LEFT COLON DO YOU PERFORM PRIMARY ANASTOMOSIS AFTER RESECTION? DO YOU EMPLOY OPEN OR CLOSED METHODS?

A study of answers to these questions revealed a decided trend away from extraperitoneal, multistage operations and a tendency toward more frequent use of the closed method of anastomosis. Three indicated that primary suture was undertaken only on rare occasion. Four others claimed a hundred per cent performance. The varied incidence of performance is recorded in Table I as well as the relative frequency of employment of the closed and open technics of anastomosis.

Sixty-two per cent of the combined groups estimate that they use primary anastomosis in 75 to 100 per cent of cases, 36 or 72 per cent of them use this method in 50 per cent or more of cases. In the smaller group 60 per cent believe they employ this method in less than 25 per cent of instances, the remaining four estimate a performance of 90 per cent or better. Sixty per cent of the combined groups use a closed method, in the smaller group there is an even division.

A difference of opinion prevails as to which single factor is chiefly responsible for reasonably safe accomplishment of resection and immediate anastomosis, but most of the surgeons who made special comment on the subject considered the following to be contributory: (1) The advent of chemotherapeutic agents for oral use during the preoperative period, (2) a better understanding and utilization of preoperative preparation, especially as regards anemia and serum protein deficiency, and (3) improvement in anesthetic methods. In addition to these influences, a number of surgeons, especially Stone,⁹ believes that a closed type of anastomosis contributes materially to the success of this undertaking. Somewhat more controversial are values placed on antecedent or concomitant use of decompressive measures.

In 1942 Stone, in a valuable contribution to the subject in which McLanahan collaborated, gave considerable impetus to the developing trend toward resection and immediate anastomosis of the colon. More recently technical methods and reasons for preference of primary anastomosis over extraperitoneal resection have been reported by White and Amendola,¹⁰ Whipple,¹¹ Waugh and Custer,¹² Clute and Kenney,¹³ Myer, et al.,¹⁴ Hoxworth,¹⁵ Wangenstein,⁸ MacFee,¹⁶ and Ravdin.¹⁷

T. E. Jones,¹⁸ Rankin,¹⁹ Lahey,^{20, 21} and David²² have repeatedly urged that the old-type Mikulicz operation not be confused with the newer concept of extraperitoneal resection, exemplified by the obstructive resection of Rankin. They believe that in many, if not in most instances, an exteriorization measure, rather than primary suture of the bowel, is the proper choice.

TABLE I—*Resection and Immediate Anastomosis of the Distal Colon*

	Incidence of Performance			Method of Anastomosis		
	5-24%	25-74%	75-100%	Closed	Open	Both
Group I (40 Surgeons)	2(5%)	11(27%)	27(67%)	25(62%)	11(27%)	4(10%)
Group II (10 Surgeons)	6(60%)	0	4(40%)	5(50%)	5(50%)	0
Total	8(16%)	11(22%)	31(62%)	30(60%)	16(32%)	4(8%)

that ample statistical data on resectability, mortality and five-year survivals attest the adequacy of this mode of resection, by which as great an extent of colon and gland-bearing mesentery can be removed as in resection and imme-

diate anastomosis Jones still employs obstructive resection altogether for lesions of the distal colon, David in all but 5 to 10 per cent of cases, and, Lahey, and Cattell in all but 10 per cent of such lesions

MacFee,¹⁶ long an advocate of primary anastomosis as the procedure of choice, recently aptly expressed the concern with which a number of us have viewed the all-or-none attitude adopted by many surgeons in regard to primary suture of the distal colon after resection. It reads "When primary resection is intended and an unforeseen complication is encountered, there is always the inclination to proceed with the definitive operation as planned, bearing in mind, but at the same time disregarding, the fact that conditions for the operation are not ideal. The results may be chastening to the surgeon, and irreparably bad for the patient. It is the middle ground cases that offer the greatest temptation and, therefore, the greatest danger." Actually, McFee has been able to accomplish primary anastomosis after resection in not more than 25 per cent of his cases.

Controversy continues concerning the relative merits of the closed and open methods of intestinal anastomosis. Despite strenuous criticism by Whipple,¹¹ Meyers,¹⁴ and others, of the aseptic technics, particularly those that employ special clamps, their popularity has grown steadily since 1937, when a survey made by us revealed almost universal preference for the open anastomosis. Stone, Rankin, Wangenstein, Vaughn White, Pemberton and Dixon are among those who believe mortality is favorably influenced by the closed technic. Collei,²¹ who says that the aseptic method of anastomosis has become increasingly popular with their surgeons, believes that the striking point of difference between the two methods is not that peritonitis is more apt to occur with the one or the other, but that with any open anastomosis there is a high risk of contamination of the abdominal wall which withstands infection less well than the peritoneum.

DO YOU ROUTINELY ESTABLISH COMPLEMENTARY PROXIMAL DRAINAGE?

Results of this phase of the survey are shown in Table II. Fifteen, notably Ravdin,¹⁷ Dixon,²¹ R. Graham,²⁵ White,¹⁰ Whipple,^{11, 26} and Fallis,²⁷ regularly establish complementary drainage by means of cecostomy, transverse colostomy or appendicostomy, seven preliminary to resection and anastomosis and the remainder at the time of operation. Tube cecostomy is favored over other methods. Only three expressed preference for the Devine type of colostomy. A number of those who commented on this procedure consider it unnecessarily complicated and are in agreement with Dennis,²⁸ Fallis,²⁷ and Wangenstein,²⁹ who believe satisfactory defunctionalization and decompression can be attained by a simple loop colostomy. Stone,⁹ Vaughn,¹² Meyer, et al,¹⁴ and Wangenstein⁸ have recently taken positive stands to the effect that proximal drainage is not essential to a low mortality in primary suture of the left colon. Ravdin¹⁷ considers decompression with the Miller-Abbott tube before, during and after resection to be an important contribu-

TABLE II—*Complementary Drainage in Resection of the Left Colon*
(50 Surgeons—Group I, 40, Group II, 10)

Routine Employment of Surgical Decompression	
Group I	11 (27.5%)
Group II	4 (40.0%)
Both	15 (30.0%)
Preliminary to Resection	
Group I	5
Group II	2
Both	7 (47.0% of 15)
At Time of Resection	
Group I	6
Group II	2
Both	8 (53.0% of 15)
Types of Decompression	
Cecostomy	6
Transverse Colostomy	4
Cecostomy or Colostomy	4
Appendicostomy	1
Miller-Abbott Tube	5
Wangensteen Suction	17

tory factor in the reduction of mortality in primary resection. Although the tube did not always go through the ileocecal valve, Ravdin found it frequently did and thus obviated the necessity of a proximal drainage operation in many lesions of the distal segments of the colon. Only four other surgeons indicated that they made regular use of long tube decompression. Seventeen find decompression by means of an indwelling duodenal tube adequate in most instances.

DO YOU ROUTINELY EMPLOY CHEMOTHERAPY? PRELIMINARY TO, OR AT THE TIME OF OPERATION? IN WHAT FORM?

The answers to these questions are recorded in Tables III and IV. Forty-two, or 84 per cent, indicated regular use of chemotherapeutic agents. The small minority is equally divided between the two groups, constituting 10 per cent of the larger and 40 per cent of the smaller group. Twenty-seven limited use of the sulfonamides to the preoperative oral administration of sulfasuxidine or sulfathalidine. Fifteen, at the time of operation also instilled sulfanilamide or sulfathiazole into the peritoneal cavity. All but one of these are of the larger group. Penicillin is utilized postoperatively for periods of from three to ten days by 22. Only five regularly employ oral streptomycin preoperatively. Four others give sulfadiazine, orally or intravenously, as the drug of choice.

It is difficult to evaluate the favorable influence of any one therapeutic agent. This is particularly true of the sulfonamides and antibiotics for there have been no large series of cases reported in which adequate controls, run concurrently, have been provided.

Stone, Lahey, Cattell, Jones, Wangenstein and Guid either use chemotherapy rarely or not at all. Allen³⁰ expressed the conviction of a number

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TABLE III—*Chemotherapy in Surgery of the Large Intestine*
(50 Surgeons—Group I, 40, Group II, 10)

Routine Use of Chemotherapeutic Agents	
Group I	36 (90 0%)
Group II	6 (60 0%)
Both	42 (84 0% of 50)
Preoperatively, Only	
Group I	22 (61 0%)
Group II	5 (83 0%)
Both	27 (64 0% of 42)
Preoperatively and at Operation*	
Group I	14 (39 0%)
Group II	1 (17 0%)
Both	15 (36 0% of 42)
*Sulfanilamide, 14, sulfathiazole, 1	

TABLE IV—*Chemotherapy in Surgery of the Large Intestine*
Types of Agents Employed

Preoperatively (Orally)	
Sulfasuxidine or thalidine	33
Sulfadiazine	4
Streptomycin	5
	—
	42 (84% of 50)
At Operation (Intraperitoneally)	
Sulfanilamide	14
Sulfathiazole	1
	—
	15 (36% of 42)
Postoperatively	
Penicillin	22
Streptomycin I M	1
Sulfadiazine I V	4
Sulfathalidine, orally	(5)*
	—
	27 (64% of 42)

*Also uses penicillin

who have communicated with us when he said, "The added benefits of chemotherapy have doubtless played a role, but we believe too much credit has gone in this direction. Carefully controlled anesthesia, blood replacement, and better technical surgery, have really been the chief reasons for better results in our opinion." Pemberton,³¹ on the other hand, feels that changes which have occurred in surgery of the colon since the introduction of chemotherapy have been "as spectacular and revolutionary as the changes wrought by iodine therapy in surgery of exophthalmic goiter." Other than use of chemotherapy, he stated, there had not been any major change in the management of colonic and rectal carcinoma at the Mayo Clinic during the past ten years, yet the over-all mortality rate progressively decreased after the routine employment of chemotherapy was instituted.

Ravdin,¹⁷ et al, recently said that since the action of oral sulfonamides on intestinal bacteria is highly selective, the usual or even larger, doses are

occasionally without marked effect Streptomycin, on the other hand, was found to be effective in part, at least, against all common intestinal pathogens They noted that when given by mouth in a dosage of 0.25 Gm every six hours the feces are free of streptococcus fecalis in eight days, and there results a marked reduction in the coliform group and anaerobic organisms of the Welchii type They are now studying the effect of 5.0 Gm daily to determine whether bacterial control is achieved in a shorter period of time

It is apparently not generally known, as Poth,³² et al, have demonstrated, that sulfathalidine and penicillin are antagonists Sulfasuxidine must be used if penicillin is to be administered simultaneously Yet, five with whom we corresponded said they administered postoperatively both sulfathalidine and penicillin

DO YOU ROUTINELY PRACTICE ANTERIOR RESECTION OF THE RECTOSIGMOID WITH IMMEDIATE RESTORATION OF CONTINUITY? OR ONLY IN HIGHLY SELECTED CASES?

Only nine, or 18 per cent, of the 50 surgeons in this survey indicated that they regularly undertake this procedure for operable growths (Table V) Seven of these are in the larger group Twelve, or 24 per cent of the total signified that they never perform this operation, whereas 14 of the remaining 29 especially commented that they consider it justifiable only as a palliative measure when liver metastasis existed Of the remaining 15 who indicated use of this method in highly selected cases, half further qualified their answer by appending such terms as, "rarely ever," "very seldom," or "rare," underscored As evidence of a trend away from anterior resection are statements volunteered by eight to the effect that formerly they favored this measure as the operation of choice in all cases, but now use it only as an expedient or not at all White³³ and several others in this group give credit for their decision to the recent (1947) report of Gilchrist and David³⁴ on their pathologic studies of lymphatic spread in cancer of the rectum The objection to anterior resection most frequently expressed is the high incidence of local recurrence Others were influenced by a high morbidity resulting from leakage at the suture line, with subsequent pelvic infection, fistula formation or occurrence of stricture at the site of anastomosis

The principal advocates of anterior resection of the rectosigmoid are Dixon,²⁴ Wangenstein,⁸ and Mahorner³⁵ Their thesis is simply this (1) carcinoma of the rectosigmoid does not ordinarily metastasize downward, (2) contrary to longstanding belief, the superior hemorrhoidal vessels may be sacrificed without impairment of the circulation of the divided ends of sigmoid and rectum, and, (3) avoidance of colostomy is a pre-eminently humanitarian consideration Even were it assumed that there is a greater chance of recurrence with this type of operation, Mahorner³⁵ feels that "it may be justified on the grounds that many patients who are saved with colostomies are broken in spirit and morale to such an extent that in reality they would

TABLE V—*Anterior Resection of Rectosigmoid*

Routine Employment	
Group I	7 (17.5%)
Group II	2 (20.0%)
Both	9 (18.0% of 50)
Rare Employment	
Group I	25 (62.5%)
Group II	4 (40.0%)
Both	29 (58.0% of 50)*
No Employment	
Group I	8 (20.0%)
Group II	4 (40.0%)
Both	12 (24.0% of 50)

*Use limited to inoperable cases by 14

be more fortunate to have been lost at the time of their operation. Forty people saved with a sphincter may be worth 50 people saved with permanent colostomy."

To date, the number of cases undertaken by this method has been too small in any one series, and the length of time which has elapsed since they were undertaken has been too short, to permit its proper evaluation. Waugh,¹² Wangenstein,⁸ and Mahorner³⁵ have extended the scope of anterior resection to include ampullary lesions, which will be discussed subsequently.

DO YOU CONSIDER THE COMBINED ABDOMINOPERINEAL RESECTION THE OPERATION OF CHOICE FOR CANCER OF THE RECTUM AND RECTOSIGMOID? OR FOR THE RECTUM ONLY? OR DO YOU CONSIDER THE OPERATION OF CHOICE TO BE THAT ADVOCATED BY BACON IN WHICH COLOSTOMY IS ELIMINATED?

Forty-one, or 82 per cent, indicated the Miles operation as the procedure of choice both for lesions of the rectum and the rectosigmoid. The remaining nine qualified their answers with supplemental statements. Two of these employ the Miles operation for all rectal lesions, reserving anterior resection for those of the rectosigmoid. Seven routinely perform anterior resection not only for lesions of the rectosigmoid, but also for lesions at varying levels of the rectum as follows: three for all lesions more than 10 cm above the pectinate line (one employs a pull-through operation for small, early growths), two for all lesions more than 5 cm above this line, one for selected, small growths more than 6 cm above the anus, and, one for all lesions at least 3 cm above the ano-rectal line (Table VI). All employ the Miles operation when cancers are situated below the levels which have been indicated. Nine who had in recent years performed an occasional operation of the Bacon type expressed dissatisfaction with the procedure and a disinclination to employ it in the future. No one indicated proctosigmoidectomy as the procedure of choice.

Waugh³⁶ supplemented his answers to these questions with the observation that he had used the pull-through operation of Babcock and Bacon in over 100 patients whose lesions were between 5 and 10 cm from the pectinate

TABLE VI—*Choice of Procedure in Cancer of the Rectum and Rectosigmoid*

Miles Operation	
Group I	33 (82.5%)
Group II	8 (80.0%)
Both	41* (82.0% of 50)
Anterior Resection	
Group I	6 (15.0%)
Group II	1 (10.0%)
Both	7* (14.0% of 50)
Proctosigmoidectomy (Bacon)	0

*Two others employ Miles operation for all but rectosigmoidal lesions

*For lesions 10 cm above anus (3), 5 cm above (2),
6 cm above (1), 3 cm above (1)

line with a mortality of less than 1 per cent. Although he believes that if used advisably, this procedure is as curative as the Miles operation, he nevertheless found anal function to be not as good as it is following anterior resection and for this reason has extended downward the scope of the end-to-end anastomosis to include growths 5 cm above the anus. For lesions below this level Waugh prefers the Miles operation. Wangenstein³⁷ in his additional remarks said that he reserved the abdominoperineal procedure for large, fixed ampullary growths and for all growths lying within 6 cm of the anus. He further commented that the Babcock-Bacon type of operation, which he had performed on a number of occasions in recent years "fails to preserve the internal sphincter and in consequence fails to preserve continence." Also recently, in remarking on Babcock and Bacon's assertion that sphincterless perineal colostomy is to be preferred to abdominal colostomy, he said "Whereas for sentimental reasons, the perineum may appear to be a more desirable location for an artificial anus, it would seem better to have such an opening where it may come more directly under the watchful eye of its owner."

Daniel,³⁸ who indicated that he considers the Miles operation the method of choice for all rectal lesions, provided unpublished statistics of his recent personal experiences with 20 anterior resections of the rectal ampulla in which primary anastomosis was done, 24 resections of the Babcock-Bacon type, and 34 abdominoperineal resections, all performed between December 1, 1945 and February 1, 1947. The incidences of secondary metastasis, or re-appearance at the operative site, were (1) for anterior resection, 15 per cent, (2) for the Babcock-Bacon procedure, 30.38 per cent, and, (3) for the Miles operation, 1 wound metastasis, or 3.4 per cent. In a previous study³⁹ there were 22 wound metastases in 257 cases of abdominoperineal resection and colostomy and perineal resection, or an incidence of 7.7 per cent. Recurrences in the anterior resection were all in the bowel itself. Of the seven secondary metastases in the pull-through operations in three instances perirectal nodes and fat were involved and in four there was no discernable involvement outside the bowel wall.

Of those who utilize anterior resection or the pull-through operation for rectal growths, only a few, notably Babcock, Bacon, and Garlock, include lesions situated as low as 3 cm from the ano-rectal line. Wangenstein⁸ is convinced, despite the failure of Collier and his associates to find evidence of lateral lymphatic spread in lesions lying more than 3 cm above the anus, that in low-lying lesions, failure to excise the levator muscles in juxtaposition to the bowel invites local recurrence. "I have learned," he states, "the bitter lesson that it is unwise to attempt to salvage sphincters in such low-lying lesions. If one does so he compromises on the cure."⁴⁰

It is interesting to observe that the proponents of the two conflicting schools of thought in the treatment of cancer of the rectum both find inspiration and guidance in the several pathologic studies of lymphatic spread in rectal cancer. The most enthusiastic champions of preservation of the anal sphincteric mechanism, Babcock, Bacon,⁴² Lynch,¹ Waugh,¹² and Wangenstein,⁸ have all pointed to the common finding of these investigations namely, infrequent retrograde or downward spread of rectal cancer as justification for operative methods which eliminate colostomy. On the other hand, the staunchest supporters of the principles of Miles include four surgeons—Gabriel,⁴ Collier,⁶ Gilchrist^{5, 34} and David^{5, 34}—who have played important roles in demonstrating the pattern of lymphatic metastasis in cancer of the rectum. The latter two, as a result of their most recent (1947) study, concluded that "Lesions which are partially or completely below the peritoneal reflection have a high incidence of local and liver recurrences and pull-through or sleeve resections are not much better than a local resection. The Miles operation seems to give the best chance of cure here." Rankin,^{43, 44} Jones,⁴⁵ Lahey, Stone, and many others have referred to these pathologic studies as additional proof of the necessity for the radical rather than the conservative resection of the rectum. Jones⁴⁵ found that the relatively high incidence of local recurrence in the cases recently reported by Gilchrist and David "proves further that radicalism is necessary and that revival of the pull-through operations and low anastomosis will be short-lived." Along these same lines Rankin⁴⁴ said that "Since Miles' epic publication there have been innumerable surgeons, both great and small, who have tried to develop many procedures for the preservation of the anal sphincter in the treatment of cancer of the rectum. In the light of the recent anatomic studies of the lymphatics of the perirectal and pelvic tissues carried on by David and Gilchrist and again by Collier, et al, there seems little justification for their efforts."

SUMMARY AND CONCLUSIONS

1. A survey by questionnaire was undertaken to determine current trends in the surgical treatment of cancer of the distal colon and rectum as practiced by 50 surgeons with relatively large experience in this field. The opinions of 10 of these whose pre-eminence few would question have been contrasted with those of the remainder of the group. Identical opinions of approximately 20

qualified colleagues of these 50 are not included in this survey. The departments of surgery of 31 medical schools and seven clinics are represented.

2 There was noted a decided trend away from extraperitoneal, multi-stage operations for lesions of the distal colon. Sixty-two per cent of the combined groups estimate employment of primary anastomosis in 75 to 100 per cent of cases. In the smaller group 60 per cent believe they use this method in fewer than 25 per cent of instances, the remaining four estimate a performance of over 90 per cent.

3 Sixty per cent of the combined groups use a closed method of anastomosis, in the smaller group there is an even division between this and the open technique.

4 Fifteen, or 30 per cent, routinely establish complementary proximal drainage by means of appendicostomy, cecostomy, or transverse colostomy seven preliminary to resection and anastomosis and the remainder at the time of operation. Three expressed preference for the Devine type of colostomy. Seventeen find decompression by means of an indwelling duodenal tube adequate in most instances. Five regularly utilize decompression by the Miller-Abbott tube before, during and after resections of lesions in the distal colon.

5 Forty-two, or 84 per cent, indicated regular use of chemotherapeutic agents. The small minority is equally divided between the two groups, constituting 10 per cent of the larger group and 40 per cent of the smaller one. Twenty-seven limited the use of sulfonamides to the preoperative administration of sulfasuxidine or sulfathaladine. Fifteen, or 36 per cent, of the 42 who regularly utilized chemotherapy also instill either sulfanilamide or sulfathiazole into the peritoneal cavity at the time of the operation. All but one of these are of the larger group. Five regularly administer oral streptomycin preoperatively. Twenty-two use penicillin postoperatively.

6 Only nine, or 18 per cent, regularly perform anterior resection of the rectosigmoid for operable lesions. Seven of these are in the larger group. Twelve, or 24 per cent, never undertake this procedure, whereas 14 of the remaining 29 consider it justifiable only as a palliative measure when liver metastasis exists. Of the residual 15 who indicated use of the method in highly selected cases, half further emphasized infrequency of employment by appending such terms as, "rarely ever" or "very seldom." Eight commented on their former routine use of anterior resection which they no longer consider a proper procedure.

7 Forty-one, or 82 per cent, indicate the Miles operation as the procedure of choice both for lesions of the rectum and rectosigmoid. Two of the remaining surgeons elect the Miles operation for all lesions except those involving the rectosigmoid, for which they prefer anterior resection. Seven regularly practice anterior resection for all rectosigmoidal growths and for rectal growths located as follows: three for lesions which are at least 10 cm above the ano-rectal line (one occasionally uses a pull-through operation for

small, early growths), two for those 6 cm above this line, and one each for lesions situated respectively 5 and 3 cm above the anus. Nine who had in recent years performed operations of the Babcock-Bacon type expressed dissatisfaction with the procedure and a disinclination to employ it in the future. No one indicated proctosigmoidectomy as the operation of choice.

8 From the foregoing expressions of opinion by those in this country who probably undertake most of the surgery of the large bowel for cancer, it would seem that one may properly conclude that there no longer exists cause for the concern felt by many of us, and expressed before this Association last year by Allen,³⁰ over what appeared to be a widespread revival of interest in operations upon the rectum that include preservation of the anal sphincter. It would now appear that a transient trend in that direction has, as Jones⁴⁵ recently predicted, the probability of being short-lived. One trend, however, will in all likelihood end in universal acceptance in suitable cases. Reference is made to the steadily growing tendency to perform single-stage rather than multi-stage operations for lesions in every segment of the large intestine. This is accomplished for the transverse, descending and sigmoid portions of the colon by immediate anastomosis after resection and for the rectosigmoid and rectum by a one-stage combined abdominoperineal resection.

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FAMILIAL POLYPOSIS AND CARCINOMA OF THE COLON*

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POLYPS OR POLYPOSIS OF the large intestine and their relationship to the etiology of cancer have for many years been the subject of study by those interested in colon surgery. Most observers have accepted Erdmann and Morris¹⁰ division of polyps of the colon into two distinct groups.

- 1 Single or multiple polyps developing largely in adults as *simple* neoplasms of the mucosa (Adenomata), or *secondary* to or in association with acute or chronic inflammatory disease such as ulcerative colitis
- 2 Diffuse multiple polyposis (polyposis intestini) found in childhood, adolescence or early adult life, where often the entire colon and rectum will be diffusely involved, with marked hereditary and familial background as a basis for its occurrence and a great likelihood for carcinoma developing at an early stage

While diffuse familial polyposis has been regarded as relatively rare in occurrence, Scarborough¹⁸ was able to collect 301 cases reported in the literature up to 1937, and McLaughlin²⁷ 331 up to 1943. Since then 24 more cases have been placed on record (McLaughlin,²⁷ Pugh and Nesselrod,³² Hickman,³¹ Pfeiffer and Patterson,³³ Rachet, Busson, Galmiche and Rosey,²⁵ Laveuf, Laurence and Poneche,³⁰ and Guptill³⁴)

In 1930 Dukes¹³ was able to collect 14 reports in which one or more families with hereditary multiple polyposis had been recorded and since then 22 more have been added to the record. Guptill³⁴ reviewed 58 cases treated by surgery up to 1947. The number of these reports indicates that familial colon polyposis while formerly considered rare actually cannot be too uncommon.

A recent extraordinary experience with a family in which a very high incidence of diffuse polyposis of the colon and subsequent cancer was found, is the basis of this report.

Case 1—Male—25 years of age, single, was my first contact with this family. In November, 1942, three months before examination, while in U S Army service, he began to have pain in rectum after defecation and bloody, frequent stools. He was unrelieved by medical measures and was discharged from the army and returned home for surgical treatment. His family history was negative except that his mother had died of carcinoma of the sigmoid at 41 years. There had been no loss of weight. His physical examination was essentially negative except for the rectum. Rectal examination revealed an ulcerating mass 3 cm in diameter on the anterior wall just within the anal sphincter. Proctoscopic examination, besides the ulcerating mass, showed numerous bleeding polyps of the rectum and sigmoid. Adenocarcinoma Grade II was reported from the biopsy taken from the ulcer.

On November 11, 1942 abdomino-perineal resection of rectum and sigmoid was done. 37 cm of gut removed. The entire rectum and sigmoid were densely studded with polyps 1 to 6 mm in diameter. The ulcerating mass on the anterior rectal wall close to

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the sphincter was polypoid—measured 4 cm in diameter. Microscopic examination showed Adenocarcinoma Grade II (Fig 1). The regional lymph nodes were found negative for evidence of malignancy.

He made an uneventful recovery except for a perineal abscess that required draining 9 mos and again 14 mos after operation. Subsequent roentgenogram of remaining colon showed diffuse polyposis of transverse and descending colons but he rapidly gained 35 pounds in weight, was married and refused all further surgery (Fig 2).

Five-year follow-up examination. The end colostomy is functioning well. He has occasional mild bloody diarrhea, but normally two stools a day. Perineal wound well healed. No evidence of local recurrence. Definitely overweight—205 pounds. He will eventually require total colectomy and permanent ileostomy. No evidence of abdominal mass or intestinal obstruction to date.

Case 2—Fifteen months after treating Case No 1, his brother, 29 years of age, appeared for treatment. He was married and had two children 5 and 3 years of age. One year before he had been hospitalized for three months for treatment of a compound

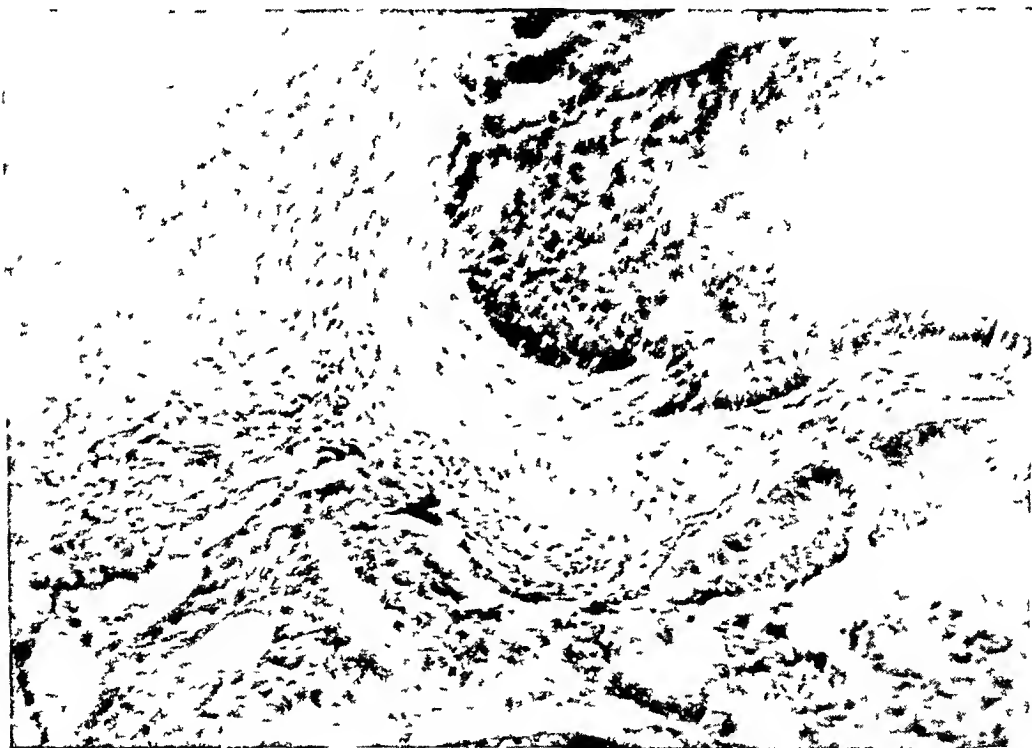


FIG 1—Case 1 Adenocarcinoma of rectum superimposed on multiple polyposis

fracture of the tibia. He recovered function of his leg slowly. For six months he had had occasional diarrhea, anorexia, easy fatigue, and had lost 45 pounds in weight. Eight years before he had been treated elsewhere for multiple rectal and sigmoidal polyps, with removal of one large benign rectal polyp. On physical examination he showed marked emaciation, a large nodular liver and a mass in the upper left abdomen indistinctly outlined. Rectal examination was negative.

Exploratory laparotomy February 7, 1944 revealed a huge carcinoma of the sigmoid, involving 10 to 12 cm, but no apparent obstruction to the lumen of the gut, many enlarged retro-peritoneal glands, massive metastases to the liver. The huge right lobe of the liver formed the mass in the upper left abdomen. A nodule removed for

biopsy showed Adenocarcinome Grade II. He recovered uneventfully from the exploration but died at home on April 28, 1944. No autopsy was obtained.

Since two members of this family had developed carcinoma superimposed upon multiple polyposis of the rectum and sigmoid and since the mother had died of cancer of the sigmoid, and a sister had died elsewhere apparently from advanced carcinoma of the sigmoid, a thorough investigation and complete health record of the remaining members of the family, with details of the



FIG 2—Case 1 Multiple polyposis of transverse and descending colons

final illnesses of the mother and daughter who had died, seemed definitely indicated.

This was a family of Italian extraction, consisting of a man and his wife and seven children, one of whom died in infancy. The histories of the second and fourth children have been recorded above. The health record of the remain-

ing members of the family are as follows

FATHER No family history of cancer

Details of health of relatives unknown—living in Italy

For years he had been overweight Had had a thyroidectomy for toxic adenoma

Hypertension

(Died later at 68 years of age of cerebral hemorrhage)

MOTHER *Family History*—Father died at 40 years, cause unknown Carcinoma?

Mother, three brothers and one sister living and well

One brother died in infancy

At 37 years of age (1928) developed an acute intestinal obstruction Following an emergency colostomy for its relief, an anterior resection of the sigmoid was done for a constricting adenocarcinoma The restricted specimen showed a benign

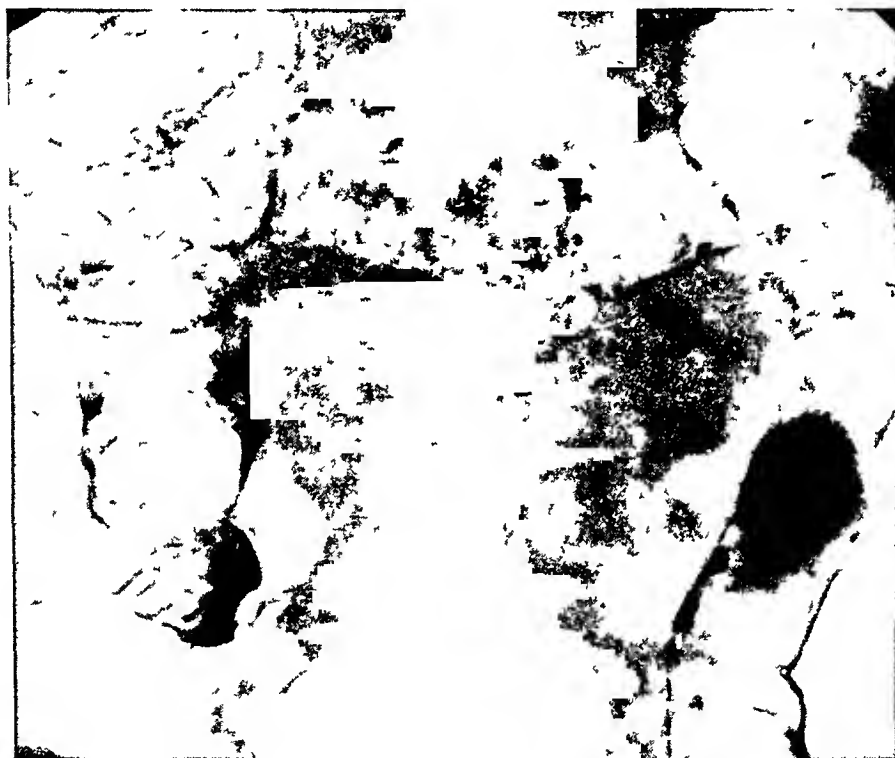


FIG 3—Case 6 Multiple polyposis of ascending, transverse and descending colons

polyp proximal to the growth and at operation polyps were palpated in the descending colon Died at 41 years, $3\frac{1}{2}$ years after operation, from general peritoneal carcinomatosis—proven at autopsy (Information obtained through the courtesy of Dr D K Santee, Bethlehem)

CHILDREN *Child 3* Female—24 years—single

Following a six-months' history of intermittent abdominal pain—occasional diarrhea, fatigue, anorexia and loss of weight, exploratory laparotomy revealed an advanced carcinoma of the sigmoid with polyps in the sigmoid and descending colon and intraperitoneal metastases She died three months later (1941) No autopsy (Information obtained through the kindness of Dr Leonardo, Rochester, New York)

The three remaining children were contacted and agreed to examination

CHILD I Female—35 years (1944)—2 children, 6 and 1 yr

Free of all symptoms referable to disturbed bowel function Normal bowel habit
Routine Examination revealed

- 1 Rectum and pelvis negative to palpation,
- 2 Proctoscopic examination—Negative for polyps or neoplasm up to mid-sigmoid
- 3 Barium double contrast enema revealed diffuse polyposis of transverse and descending colons

Colectomy advised, but operation refused because of lack of symptoms and family economic demands

CHILD I Three-year follow up—She is still without symptoms

Check roentgenogram shows polyposis of sigmoid and descending colon One polyp in sigmoid destroyed by fulguration No evidence of malignancy (Dr Leonardo)

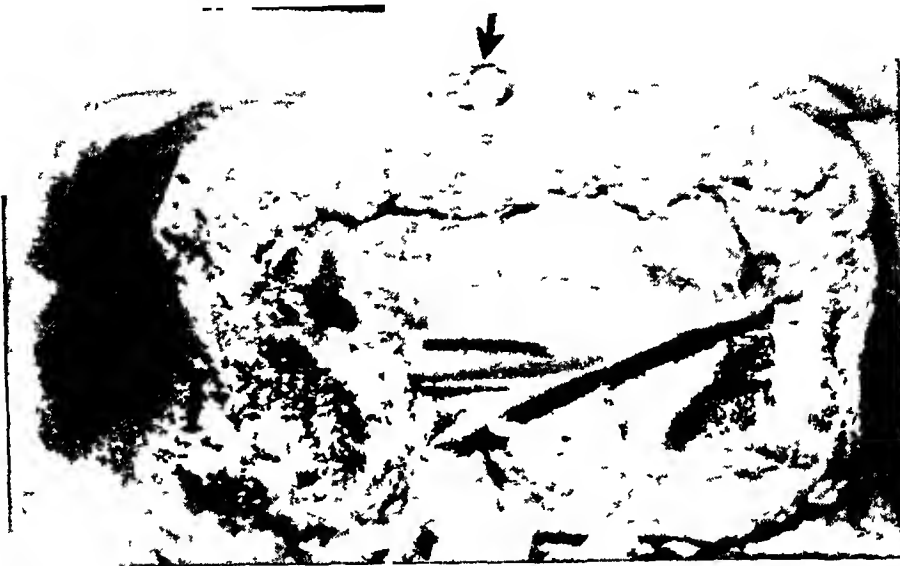


FIG 4—Case 6 Entire colon resected—studded with polyps—one very large polyp in transverse colon

CHILD V Male—29 years (1947)—unmarried

Absolutely symptom free Normal bowel movements

Defecation three to four a day

Routine Examination revealed

- 1 Rectum examination showed one palpable polyp on the anterior wall
- 2 Proctoscopic examination revealed numerous discrete sessile polyps, approximately 4 to 8 mm in diameter, as far up as the middle of the sigmoid
- 3 Barium double contrast enema—refused for the present

Case 3—CHILD VI Female—23 years (1944) Unmarried Symptom free In good health Proctoscopic examination revealed multiple polyps of rectum and sigmoid, discrete and not confluent

Double contrast enema by roentgen showed multiple polyposis of ascending transverse and descending colons (Fig 3)

As the polyps in the rectum and sigmoid, though numerous, were discrete, local destruction by fulguration was advised to be followed by ileosigmoidostomy and total colectomy Accordingly after the rectal and sigmoidal polyps were destroyed and the rectum and sigmoid had remained free of all evidence of recurrence for six weeks, on July 14, 1944 ileosigmoidostomy was done with further local removal of polyps in sigmoid at site of anastomosis Many polyps in transverse and descend-

ing colon could be palpated. Following uneventful recovery from the above procedure on November 3, 1944—the ileum distal to the ileosigmoidostomy, the entire colon—cecum, ascending, transverse, descending colon and upper sigmoid were resected. The colon removed measured 65 cm in length. The mucosa everywhere was studded with polyps—over 100 were counted. The largest was in the transverse colon—3 cm in diameter and 2½ cm long (Fig 4). Though this large polyp was definitely a pre-cancerous lesion, no evidence of malignancy could be detected.

Microscopic diagnosis—benign polyposis.

Three-year follow up—She is in good health, has occasional abdominal pain—has required further fulguration for rectal and sigmoidal polyps. She now has 15—20 polyps, all discrete, in rectum and rectosigmoid. Visualization to mid-sigmoid anastomosis is easy. Further destruction by fulguration advised and re-examination in six months.

The children of the third generation are all at present symptom free and seem too young for satisfactory complete diagnostic survey. It has been recommended that if bowel symptoms or melena develop, immediate examination will be imperative and as they attain 12 or 13 years of age (puberty) a complete study should be made.

While diffuse polyposis has been found at an early age, 2 years or even at birth (McKenney),¹⁵ Kennedy²⁹ believes it is rare in children.

The history of this family may be summarized by the following diagram (Fig 5).

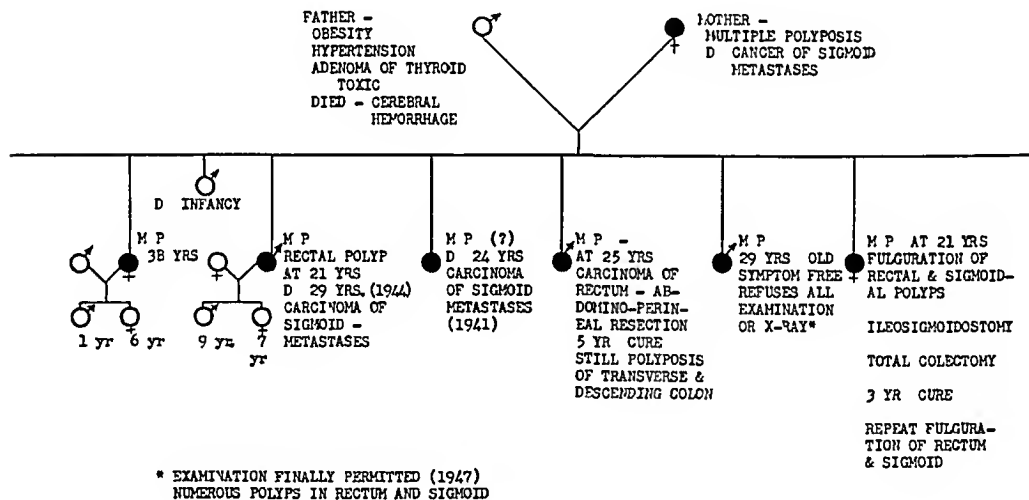


FIG 5—History of family summarized

COMMENT

A woman, whose father probably died of carcinoma and who, at 37 years of age, had a carcinoma of the sigmoid with polyposis of sigmoid and descending colon, had seven children. One died in infancy. *Of the remaining six all have either died of carcinoma of the sigmoid with previous polyposis of the rectum and colon, or have been shown to have multiple polyposis of the colon and rectum with or without carcinoma.*

This extraordinary family history illustrates again the remarkable hereditary tendency of multiple diffuse colon polyposis to be transmitted to succeeding generations and the high incidence of cancer associated therewith, and

furthermore, demonstrates that both males and females may transmit and acquire the disease

Likewise, the fact that in three of the family who were completely symptom free, thorough investigation revealed well established colon polyposis, indicates *the fallacy of reliance upon history or symptoms alone as indicative of the presence or absence of disease*. Individuals of these susceptible families can be considered *free of the disease only after complete diagnostic survey* fails to reveal any vestige of polyposis or cancer

A single negative survey, even in an adult, is not sufficient indication that the individual will remain free of the disease. Lockhart-Mummery²⁰ cites the case of a man who at 39 years had a completely negative survey and who four years later was found to have advanced diffuse polyposis. Members of a polyposis family who are found by complete investigation to be apparently free of the disease, should have routine re-surveys every six months, or more often if bowel symptoms supervene, if they are to be adequately protected against the insidious, unheralded advent of multiple polyposis or a colon or rectal cancer.

DISCUSSION

While Scarborough refers to Menzel¹ as reporting the first case of diffuse polyposis in 1721, in modern literature Luschka,² as well as Lebert³ gave accurate descriptions of the disease in 1861, followed by Virchow⁴ in 1863, who detailed the first thorough pathological background of this lesion. A further report by Richet⁵ in 1878 was followed by Cripps'¹⁶ classical description of two cases in 1882 indicating the familial hereditary tendency of multiple polyposis. Smith's³ cases in one family were recorded in 1887. Finally in 1890 Handford⁸ called attention to the fact that *cancer* was frequently implanted upon familial diffuse polyposis. Cuthbert Dukes¹³ was able to collect 14 reports in which families with hereditary tendency to multiple polyposis had been recorded. By 1947 at least 36 instances of families with hereditary tendency to multiple polyposis had been reported (13 to 34)

Most observers agree that while multiple polyposis, or polyposis intestini as it is designated in continental literature, is not itself congenital, nevertheless, a *predisposition to tumor formation in the colon and rectum is inherited*. It must be likewise understood that any suspicious case in a suspected family even if found free of polyps is not necessarily free of the hereditary blemish. It is generally held the defect is inherited as a Mendelian Dominant, "A gene mutation"—an inherited instability of the epithelial cells of the large bowel which renders their nuclei peculiarly liable to undergo mutation for excessive rate of growth, i.e. "Mitotic Division is more frequent" (Luckhart-Mummery and Dukes)²⁰ It is transmitted by either sex and occurs in both male and female descendants

However, Friedell and Wakefield²⁸ state that one-half of the cases of diffuse polyposis seen at the Mayo Clinic do not have an hereditary factor

and deny that multiple polyposis follows any genetic pattern. They believe it is neither a mendelian dominant nor a recessive.

True familial polyposis or polyposis intestinalis may be considered a distinct entity with two characteristic features:

- 1 It tends to develop in succeeding generations of the same family—familial predisposition.
- 2 It is a pre-cancerous lesion. Cancer frequently will eventually develop upon it. Members of families with multiple polyposis tend to die of cancer of the colon or rectum or its metastases. Incidence of carcinoma in multiple polyposis is variously given statistically as 34.6% (Hulsieck¹¹), Wechsleman 50% to 60% (Dukes¹³), Baigen and Coffey 82.8%¹⁹. However, untreated cases are all likely to develop cancer. *The potential incidence of cancer following multiple polyposis should be considered 100%.*

Age Doehring¹⁹ analyzed the age of 40 cases as

Years	Number of Cases
1-10	2
10-20	10
20-30	10
30-40	13
40-50	2
50-60	2
60-70	1

In Lockhart, Mummeley and Dukes³⁰ families, the average age at which multiple polyposis was discovered was 22 years, youngest, 8 years, oldest, 43. The average age at which *multiple polyposis* was estimated to *begin* to develop was 20 years and *malignant changes* 15 years later (35 years). Untreated cases of multiple polyposis die of cancer in their early 40's.

SYMPTOMS

Multiple polyposis of colon and rectum may be *symptomless for years*. Bloody diarrhea with occasional abdominal cramps, anorexia, and loss of weight have been commonly associated with an active or advanced lesion. In families in whom one or more have been known to have multiple colon polyposis, those without symptoms should never be considered *free of the disease unless repeated diagnostic survey is negative*.

DIAGNOSIS

The diagnosis can be made by three procedures:

- 1 Digital examination of rectum (rectal polyps)
- 2 Proctoscopic and sigmoidoscopic examination
- 3 Roentgen-ray examination of colon by double contrast enemas. A simple contrast enema with barium is usually ineffective in demonstrating polyps. Colon dilatation with air following a barium enema

gives a double contrast medium that outlines most of the polyps very satisfactorily

TREATMENT

The treatment of choice is total colectomy, the complete elimination of the colon and rectum as a possible origin of future cancer, usually in three stages

- 1 Preliminary ileostomy
- 2 Resection of entire colon and sigmoid
- 3 Posterior resection of remaining rectum and rectosigmoid

However, Rankin,¹⁶ Jones,²¹ Lockhart-Mummeley,³⁰ and C W Mayo¹⁴ have all advocated a compromise procedure to preserve the rectum and rectal sphincter in those cases in which the polyps in the rectum and lower sigmoid may be destroyed by fulguration through the sigmoidoscope, i e ,

- 1 Fulguration of rectum and sigmoid
- 2 Ileosigmoidostomy
- 3 Resection of lower ileum and entire colon down to lower third of the sigmoid Hemi-colectomy may be done at the same time as the ileo-sigmoidectomy (C W Mayo)¹⁴

Guptill³⁴ recently has recommended an end to end anastomosis of the ileum to the rectum, leaving a stump of rectum 8 cm or less, which can be easily reached by the proctoscope for fulguration if rectal polyps recur. Guptill³⁴ bases this recommendation upon the need in two cases for resection of the remaining sigmoid stump for recurrent polyps—following typical ileo-sigmoidostomy. Pfeiffer and Patteison³³ likewise prefer an ileorectosigmoidostomy in order that the junction of the ileum with the sigmoid be sufficiently low.

A low union of ileum with rectum or rectosigmoid would seem highly desirable in view of the frequency with which further polypoid formation after simple fulguration is met. Certainly, if any suspicion of carcinomatous change in rectal polyposis is aroused, any idea of conservation of the rectum should be abandoned and total colectomy including the rectum should be done.

From time to time, radiation of colon polyposis has been suggested and attempted in a conservative approach to the solution of the polyposis problem but at best it has been found to be merely palliative (Dukes,¹³ Vanzant,²⁶ McKenney¹⁵). McKenney¹⁵ has reported continuing progress of tumor growth under even heavy radiation and as Guptill³⁴ well says, "Treatment by roentgen-ray would seem illogical because the well differentiated cells of the adenomas should be radiation resistant."

CONCLUSIONS

- 1 A family is reported in which the mother and all six adult children had either multiple polyposis of the colon or carcinoma of the sigmoid or rectum or both
- 2 The mother at 41 years, one son at 29 years, and one daughter at 24

years, died of carcinoma of the sigmoid associated with polyposis of rectum and colon

3 One son at 25 years had an abdomino-perineal resection for cancer of the rectum with multiple polyposis of rectum and sigmoid. He is now living and well five years after operation—with polypoid transverse and descending colons

4 Two daughters and one son who were symptom free were found to have multiple colon polyposis, one of whom subsequently had a total colectomy with ileosigmoidostomy and fulguration of rectal and sigmoid polyps

5 Multiple diffuse colon polyposis is a distinct entity characterized by

1 Tendency to develop in succeeding generations of same family with high incidence of occurrence—familial predisposition. It occurs in both males and females and may be transmitted by both

2 Carcinoma frequently or eventually will develop upon it at a relatively early age

6 It is often symptomless but may be diagnosed by

1 Rectal examination

2 Sigmoidoscopic examination

3 Double contrast (barium-air) enema, roentgen-ray investigation

7 All members of a family in whom diffuse colon polyposis is found, should be *investigated* thoroughly for evidence of the disease

8 Treatment of choice is total colectomy with or without resection of rectum. In cases in which polyps of rectum and rectosigmoid may be destroyed

by fulguration, the rectum may be saved and total colectomy with ileosigmoidostomy will suffice. If the rectum and rectosigmoid is saved, proctoscopic re-examination should be done at least every six months as recurrence or further development of rectal polyps can be anticipated. Prompt fulguration of all new polyps is imperative if development of cancer in the remaining rectum is to be prevented. If cancer in remaining rectum does develop, abdomino-perineal resection with permanent ileostomy will be required

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LOW ANTERIOR SEGMENTAL RESECTION WITH OR WITHOUT COLOSTOMY*

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A MORE DESCRIPTIVE but longer title for this paper than the one we have used would be "A comparative study of low anterior segmental resection of the colon and upper portion of the rectum for malignant lesions with primary anastomosis between the sigmoid and rectum, with or without concomitant colostomy."

This subject is controversial and the controversy is concerned principally with two points: (1) whether anterior segmental resection and primary anastomosis with or without previous or concomitant colostomy should be performed for malignant lesions in the upper part of the rectum, rectosigmoid and lower part of the sigmoid, and (2) whether any method short of combined abdominoperineal resection or what other surgeons consider an equivalent of that operation is adequate.

At one time one of us (Mayo) would have agreed whole-heartedly with those who are of the opinion that the best operation in all instances of malignant lesions of the lower portion of the sigmoid, the rectosigmoid and upper portion of the rectum is a one-stage combined abdominoperineal resection. It now becomes expedient to qualify previous expressions of opinion since it appears that in many cases a radical procedure can be performed and primary anastomosis accomplished with low immediate risk and also with a shorter period of morbidity, compared with that for the combined abdominoperineal resection. Furthermore it seems likely, that in those instances the end result of such a procedure may prove to be as satisfactory as that of the combined abdominoperineal resection.

In 1946, 266 cases in which nonpalliative, one-stage combined abdominoperineal resection had been performed three or more years previously on the service of one of us (Mayo), were reviewed and follow-up data were obtained. This study disclosed an over-all hospital mortality rate of 6.1 per cent, lymphatic involvement in 50 per cent of cases, a three-year survival rate of 86.3 per cent and a five-year survival rate of 72.5 per cent in cases in which nodes were not involved, and a three-year survival rate of 57.2 per cent and a five-year survival rate of 38 per cent in cases in which nodes were involved. In other words, of those patients considered at the time of operation to have

* Read at the meeting of the Southern Surgical Association, Hollywood Beach, Florida, December 11, 1947.

a chance for cure, 72 per cent were alive three years and 56 per cent five years after operation

On the basis of what is known about the infrequency of retrograde spread of carcinoma of the rectosigmoid and upper portion of the rectum and on the basis of technic employed for the abdominal resection of the mesentery, ligation of the inferior mesenteric vessels or superior hemorrhoidal artery, as well as for the perineal portion of the combined operation, an anterior segmental resection of the intestine seems feasible. It even can be employed in the majority of cases in which lymphatic involvement exists. If it is properly performed, and if adequate resection is possible, it is comparable in radicalness to the combined abdominoperineal resection.

TABLE I — *Situation of Lesion*

Situation above anus	Anterior segmental resection	
	With colostomy	Without colostomy
5 to 10 cm	32	29
11 to 15 cm	68	71

TABLE II — *Anterior Segmental Resection*

	Lymphatic involvement	No lymphatic involvement
With colostomy	50*	50*
Without colostomy	43	57
Total	93	107

*Same proportion as that found in a review made by one of us (Mayo) of cases in which combined abdominal-perineal resection was performed

The terms, “properly performed” resection and “adequate” resection, mean a resection carried out as high on the sigmoid colon as it would be carried out in a “properly performed” combined abdominoperineal resection. It also is of vital importance that an anastomosis anywhere in the gastro-intestinal tract should not be under tension. Therefore, if, because of a short mesosigmoid or a short sigmoid loop, the bowel cannot be resected at a satisfactory distance above the growth, a combined abdominoperineal resection is then the operation of choice.

Other contraindications to an anterior segmental resection are fixed growths, perforation and an undue amount of inflammatory reaction about the lesion, growths that are less than 6 cm above the dentate margin of the anus in most instances, and those that are 6 cm above the dentate margin in many instances. For growths situated less than 6 cm from the dentate margin, it is our opinion that the optimal results will be obtained in the majority of cases by a combined abdominoperineal resection in one stage.

A considerable amount of careful work has been done on retrograde spread of carcinoma of the rectum and rectosigmoid by many men, including Dukes, Collier, Kay and MacIntyre, Gilchrist and David, and Glover and Waugh. The various studies indicate the relative safety with which anterior segmental resection can be performed from the standpoint of malignant spread, at least in the upper third of the rectum and in the rectosigmoid, provided the dissection and resection are carried out at points at least 2 to 2.5 cm below and above the growth, as is done when combined abdominoperineal resection is performed. In only 1 per cent of the cases of far-advanced carcinoma does retrograde spread exist to any degree.

Metastasis to the liver, within limits which must be left to surgical judgment, is not per se a contraindication to low anterior segmental resection. Many palliative resections of this type have been performed but operations for this purpose do not come within the scope of this paper.

TABLE III—*Anterior Segmental Resection with Colostomy*

Type	Grade				Total cases
	1	2	3	4	
A	2	2	0	0	4
B	25	16	5	0	46
C	10	37	3	0	50
Total	37	55	8	0	100

TABLE IV—*Anterior Segmental Resection without Colostomy*

Type	Grade				Total cases
	1	2	3	4	
A	7	0	0	0	7
B	27	18	4	1	50
C	6	33	2	2	43
Total	40	51	6	3	100

MATERIAL STUDIED

In order to be as fair as possible in this study, two series of 100 consecutive cases each were studied. In each case the carcinoma was situated from 5 to 15 cm above the anus, as determined by proctoscopic examination. In one series, the anterior segmental resection and primary anastomosis was accompanied by a colostomy (usually in the transverse colon), and in the other series the same operation was performed without colostomy.

In so far as could be determined, in each series the resection of the intestine above the growth was as extensive as that accomplished by the usual type of combined abdominoperineal operation with ligation of the inferior mesenteric vessel and removal of that portion of the intestine containing the superior hemorrhoidal vessels. Also an effort was made to resect the bowel at a point at least 2 cm below the growth. If this could not be accomplished without tension on the anastomosis neither type of operative procedure was

considered suitable. In other words, with the exception of an accompanying colostomy in one series, other considerations were comparable in all cases, within justifiable limits.

Comparison of methods of surgical technic used in dealing with any pathologic lesion in any location is subject to criticism. It might be inferred that in those cases in which colostomy was performed concomitant with anterior resection, it was because of the degree of obstruction caused by the lesion, but this was only rarely the case. Usually when colostomy was performed the surgeon preferred this surgical method, the consideration usually was that of defunctionalizing the lower segment of the bowel. In dealing with this type of case, one of the authors (Mayo) has preferred and employed the one-stage segmental resection without colostomy in all cases in which it has been feasible for the past two years.

Since each series is small and the operations have been performed so recently that three-year and five-year survival rates cannot be determined, the long-time prognosis will not be considered in this paper. It is reasonable to suppose, however, that in these locations adequate segmental resection and combined abdominoperineal resection carry essentially the same prognosis.

AGE AND SEX

As might be expected, the majority of patients were in the fifth, sixth and seventh decades. The youngest of the 200 patients was 19 years and the oldest was 76 years of age.

There was an even distribution of 101 male and 99 female patients. A fairly equal division was found in each series.

SITUATION AND TYPE OF OPERATION

The situation of the lesion and the type of operation performed are shown in Table I and an analysis of cases from the standpoint of involvement of lymph nodes is shown in Table II.

GRADE AND CLASSIFICATION OF GROWTHS

It will be noted from tables 3 and 4 that, as usual, the majority of lesions were of grades 1 and 2, according to Bionders' method of grading carcinoma. Most of the growths of grades 1 and 2 which were also classified as type C, according to Dukes' classification, were of long duration. In all cases of lesions of type C, lymphatic involvement is present.

PREOPERATIVE PREPARATION AND OPERATIVE TECHNIC

No two surgeons work exactly alike and thus the technic of operations of the same type performed by different surgeons was not exactly the same. Neither was a standard type of anesthesia employed in the two series of cases. Time and space do not allow a detailed description of the variety of technics used by the various surgeons who operated on these patients.

Since the entire operative or hospital mortality rate, and particularly that portion of it which might possibly be attributed to error in technic, is small in each group, it can be said that regardless of whether or not colostomy is performed, if well-known and fundamental principles of surgical anastomosis are kept in mind, deaths will be few. The two most important factors to consider in this connection are, first, an accurate union of the ends of the sigmoid and rectum, and, next, certainty that the line of anastomosis is not under tension.

A factor that is of utmost importance in producing a favorable operative result, uncomplicated by infection, is a clean bowel to work on and, therefore, preoperative preparation is essential. Streptomycin, phthalylsulfathiazole, sulfathaladine and succinylsulfathiazole (sulfasuxidine) are at present the drugs of choice for use in preoperative preparation. In most of the cases in our two series the last-mentioned drug was used in preoperative preparation. According to the plan usually employed, about four to seven days are required for preparation of the colon for operation, the length of preparation depends on the individual situation. During this period enemas are used in conjunction with a total of 1,000 and 1,200 grs (65 to 78 Gm) of sulfasuxidine which is administered orally in divided doses every four hours.

Another very good reason for making certain that the colon is actually well prepared is that an open type of anastomosis is necessary in practically all cases because of the site of the lesion.

MORTALITY

Nine deaths occurred in the total number of 200 cases of low anterior segmental resection, with or without colostomy, in which the growths were situated from 5 to 15 cm above the anus, a mortality rate of 4.5 per cent.

In the 100 cases in which colostomy was performed concomitantly with the resection, three deaths occurred, a mortality rate of 3 per cent. One death occurred suddenly shortly after the patient awakened from the anesthesia at the time of closure of the colonic stoma. The cause is not known because necropsy was not permitted. One patient died one week after he left the hospital, after resection and colostomy had been accomplished but before the vent had been closed. Death in this case was caused by separation of the anastomosis, formation of a hematoma and infection. Another patient died on the fifth day after the primary operation, from causes unknown. Necropsy was not permitted.

The mortality rate was 6 per cent in the 100 cases in which resection and primary anastomosis were performed without accompanying colostomy. Four of the six patients who died succumbed by the eighth postoperative day, from pulmonary embolism, myocardial failure or cardiovascular accident. One patient died on the eighth postoperative day from separation at the site of the anastomosis and resultant peritonitis. The other patient died on the thirtieth postoperative day as a result of partial separation at the line of anastomosis.

Colostomy was performed but death resulted from peritonitis and shock

MORBIDITY

In comparing the two operative procedures, we found that the most striking difference was in morbidity

Of the 97 patients who survived low anterior resection with accompanying colostomy, four were out of the hospital within one month, 64 required time that extended into the second month, 28 into the third month, and one, into the fourth month. An analysis of the total time required before the surgical dismissal was granted shows that seven patients in this series were dismissed from our care in the second month, 44 in the third month, 30 in the fourth month, five in the fifth month, four in the sixth month and one patient each in the seventh, eighth, tenth and eleventh months after operation. Of the three remaining patients, one did not return for closure of the stoma and there was no further correspondence in the case, in one case the colostomy closed spontaneously seven months after the application of clamps to the spui, and in one case there was a recurrence at the site of the resection, before closure of the colostomy had been performed and so it was left open of necessity

Of the 94 patients who survived the one-stage anterior segmental resection without colostomy, 77 were dismissed from the hospital in one month or less (16 of these within two weeks and 44 more within three weeks) and 17 more were dismissed in less than two months. An analysis of the total time required before dismissal from our care altogether in this series of cases shows that 33 patients, or a third of the total, were dismissed in less than three weeks, 28 more in less than four weeks, 32 more in the second month and one more in the third month after operation

RÉSUMÉ

Two hundred cases of carcinoma of the rectum, rectosigmoid and lower portion of the sigmoid situated from 5 to 15 cm from the anus have been reviewed

In 100 consecutive cases, anterior segmental resection was performed with concomitant colostomy and end-to-end anastomosis between the sigmoid and rectum. In another series of 100 consecutive cases, the operation was essentially similar except that colostomy was not performed

It is pointed out again that rare exceptions and especially in cases amenable to these procedures, the line of lymphatic spread in the upper portion of the rectum and the rectosigmoid is upward

In the 100 cases in which the operation was accompanied by colostomy, the mortality rate was 3 per cent. In the 100 cases in which the operation was not accompanied by colostomy, the mortality rate was 6 per cent. Four of the six deaths in this group of cases were due to pulmonary embolism or were cardiovascular in origin

The greatest difference between the results of the two operations, the one with and the one without colostomy, was in morbidity

In the series in which colostomy was not performed, 82 per cent of the patients were out of the hospital within one month and about 65 per cent of the patients were dismissed from our care within that period. All but one of 94 were dismissed in less than two months after operation.

In the series in which resection was accompanied by colostomy, 4 per cent of the patients were out of the hospital but none were dismissed from our care at the end of the first month after operation. Only seven of the 97 patients were dismissed with all our care completed two months after operation. By the end of the fourth month, the operation and postoperative care had been completed in 83 per cent of the cases.

Because the surgical procedures have been performed too recently, the survival rates must be determined at a future date, at which time comparison of the eventual results of other surgical operations for carcinoma in the same segment of the bowel can be made.

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DISCUSSION—DR LON GROVE, Atlanta. I shall not attempt to discuss the merits of anterior resection because our series is small and the time elapsed since operation is too short. After discussing this problem with Wangenstein, Dixon and others, we decided approximately eighteen months ago that we would do anterior resection in properly selected cases.

During the last eighteen months we have done thirteen anterior resections for carcinoma of the lower sigmoid, recto-sigmoid and upper rectum (slides).

There have been eight of the upper rectum, one of the recto-sigmoid and four of the lower sigmoid. These patients were all prepared with sulfasuxadine and none had colostomy. The lowest growth was 6.5 cm. above the pectinate line. There have been no deaths. The last patient was operated on four days before this slide was made, but he is now ten days post-operative and they report his condition satisfactory.

We had in this series two very remarkable complications, acute cholecystitis which occurred on the tenth and eleventh postoperative days, respectively. These patients were observed for 48 hours without improvement, and then cholecystectomy was done through a right sub-costal incision, with recovery.

Prior to the first of our cases, we had seen two patients operated on elsewhere, and both had a stricture of the ampulla. It occurred to me that if we could flare the end of the sigmoid to fit the ampulla we could avoid this. The second slide illustrates how this was done.

The first twelve of these cases have had subsequent proctoscopic examination and none has shown evidence of stricture.

DR DONALD S. DANIEL, Richmond, Va. I appreciated Dr. Estes' remarkable report. It certainly emphasizes the close relationship of polyps and carcinoma. I also congratulate

Drs Graham and Mayo for bringing this most important subject, carcinoma of the rectum and colon, before us

In my discussion I would like to give an incomplete report of carcinomas of the rectum and colon Since 1938, Dr Frank Johns, Dr William Johns and I have seen 124 cases of carcinoma of the rectum and colon, of which 83 per cent were operable with an operative mortality of 4.8 per cent Of the 124 cases, 118 were admitted to the Johnston-Willis Hospital in Richmond There were 56 carcinomas of the rectum, five were inoperable, one refused operation Nine received the Kraske, and 41 the one-stage combined abdominoperineal resection No attempt was made to preserve the sphincter in any case There were three deaths, or an operative mortality of 5.7 per cent in the rectal cases

There were 68 carcinomas of the colon, 16 were inoperable, one refused operation There were seven Mikulicz' operations with two deaths There were 44 primary end-to-end aseptic anastomoses performed with the use of the Stone technic and clamps, with no deaths

I would like particularly to emphasize this last fact Here we have seven Mikulicz operations with two deaths and 44 primary aseptic anastomoses with no mortality In the light of these statistics, meager, though definitely indicative, and of our experience, we prefer primary end-to-end aseptic anastomosis as advocated by Stone in comparison with the obstructive Mikulicz, because of the following considerations

- 1 It is natural, physiologic, and aseptic
- 2 It allows a more radical removal of the pathologic colon and the underlying glandular-bearing mesentery
- 3 The morbidity and infectious complications are at a minimum.
- 4 It obviates secondary and sometimes tertiary closure of the colostomy
- 5 It allows the patient to get up earlier, which in turn may have some influence in prevention of phlebitides and the dreaded pulmonary complications
- 6 It definitely shortens the hospitalization by half, which is less expensive to the patient and, incidentally, allows more much needed hospital space
- 7 It eliminates the colostomy mental depression which retards convalescence
- 8 Last, and most important, so far as our results are concerned the mortality is definitely low

DR ROGER G DOUGHTY Columbia, S C I have no series of cases to report that would be worthy of interest, in the light of what you have just heard Recently, however, there have been two patients that I think might be called to the attention of the Association One was a relatively young woman, in whom, from the x-ray report, there was agreement on the presence of a lesion in the rectosigmoid The x-ray man passed up an area that looked a little abnormal I was not absolutely satisfied about that area of the bowel At operation this patient was found to have very definite carcinoma in the area that had first been diagnosed by barium enema as malignant She had also an equally well developed malignant area approximately ten inches higher up Resection of both lesions was done, and she was found to have malignancy in both areas developing from polyps, together with several other small polyps which were not found in the x-ray, could not be found, too small

We did a resection and end-to-end anastomosis (For a long time I have done essentially what Dr Grove has done, instead of splitting the gut, we have angled it back from the mesentery border to enlarge the opening) I was not satisfied with this anastomosis at the time, and three months later, to satisfy myself, I had a barium enema done and I received a report of constriction in the area of operation We found a stricture of moderate extent and the gut was then completely angled back and we got a good result

The second patient was a man with a mass in the epigastrium and obvious carcinoma of the sigmoid in the x-ray He had carcinoma of the rectosigmoid and also an area in the transverse colon which looked like carcinoma We were misled in this by the plates I simply want to emphasize the fact that because we have one lesion in the gut demon-

strated by x-ray, it does not mean that we might not have another

DR RICHARD B CATTELL, Boston I should like first to express my appreciation for the privilege, as a guest, of discussing these three papers on large bowel surgery.

We have had a similar family group to that presented by Dr Estes, in which congenital polyposis occurred as a mendelian dominant characteristic. At the time of our original observation 13 years ago, four of a family of five children were found to have diffuse polyposis of this type. One or more carcinomas developed in each of the four children between the ages of 32 and 39. All four are now dead from malignant disease. One had hemicolectomy and abdominoperineal resection with subsequent liver metastases, one had a palliative abdominoperineal resection, a third had carcinoma of the cecum, carcinoma of the sigmoid and carcinoma of the rectum, and the fourth refused surgery. In the past, some of us have lacked courage in advising early colectomy during the second or third decade, and I was pleased that Dr Estes urged complete removal of the colon. In one case we removed the colon, anastomosing the ileum to the rectosigmoid, and followed the patient's course at frequent intervals, doing fulguration of polyps in the rectum on each visit. We felt safe in doing this, yet carcinoma developed at the site of anastomosis, and because of the extent of the disease in spite of radical resection, I feel sure the patient will lose her life. Dr Lahey has reported one of these cases in which the patient had four simultaneous carcinomas in various positions in the colon. We have a number of patients in whom, after repeated fulguration of scattered polyps of the rectum, we have successfully removed the colon, with anastomosis of the ileum to the rectum. Based on our experience, we feel there will be few patients in whom this can be safely done and we recommend that total colectomy with ileostomy be carried out for patients with this form of polyposoid disease.

Dr Graham is to be congratulated on the large amount of material which he has accumulated and presented to us relative to the present surgical opinion for the treatment of carcinoma of the rectum. The extensive statistical data which he has so fully presented will require careful study. From our experience, we agree with him that most patients with this lesion will require abdominoperineal resection.

Dr Mayo presented a large experience with low anterior resection for carcinoma of the rectosigmoid and upper rectum, with excellent results for the period of observation. This experience, together with that previously reported by Dixon, Wangenstein and others, should permit proper evaluation of this procedure. We are unwilling to accept resection of carcinoma in this location with such a narrow margin beyond the lesion. Furthermore, we find ourselves unable to select cases suitable for this type of operation. We have employed anterior resection with anastomosis in but few cases. Even with a small lesion which we think is favorable, frequently the pathologist reports evidence of disease well beyond the area that could be determined at the time of operation.

To illustrate our position relative to carcinoma of the rectum and rectosigmoid, I should like to report on 426 patients operated upon from 1944 to 1946 inclusive. Three hundred eighty-three abdominoperineal resections were done, constituting 98 per cent of all resections performed during this period. The mortality in this group was 6 per cent, and during this time a resectability rate of 94 per cent was maintained. In view of the fact that we have reported from our clinic a large number of two-stage resections, we feel it wise to state our present position relative to abdominoperineal resection. There are still some patients with perforated lesions with abscess who are best treated by the two-stage operation. It is our opinion that some form of an abdominoperineal resection offers the best chance for cure of carcinoma of the rectum and rectosigmoid.

DR W L ESTES, JR, Bethlehem, Pa (closing) I think Dr Cattell has brought out a very important point, i.e., the question of the operation in patients with multiple polyposis, and is conservatism justified? Certainly the operation of choice is total colectomy including complete resection of the rectum. On the other hand there may be certain cases in which a more conservative attitude might safely prevail. Cases in

which the rectum is preserved have to be carefully chosen, because there are on record instances of carcinomas occurring in these rectums that have been left, in spite of fulguration of the polyps they contain. Therefore, cases in which we are conservative and leave the rectum, must be only those which can be kept under close observation following definitive treatment, and certainly if any suspicion of actual ulceration or carcinoma develops, complete removal of the rectum must promptly follow.

Furthermore, patients with a rectum remaining should be proctoscoped at least every six months. If repeated fulguration fails to control the polyposis the rectum should be sacrificed without delay.

Finally, I want to emphasize again that the members of these polyposis families who are found symptom free can never be considered free of the disease unless a complete diagnostic survey proves negative. The mere fact that they have had no symptoms in no way eliminates the possibility that they may be victims of the disease.

DR CHARLES W. MAYO, Rochester, Minn. (closing) There is one point in the examination of multiple polyposis or adenomatosis of the colon that too often is neglected. In view of the fact that in about 5 per cent of the cases of congenital colonic polyposis there also are polyps in the stomach or small intestine, roentgenographic studies of these portions of the digestive tract should be included for complete examination in each case.

To close the discussion of my own particular presentation on the subject of low segmental anterior resection and primary anastomosis, I might say that when a malignant lesion exists in the region 5 to 15 cm. above the anus, preparation for a one-stage combined abdominoperineal resection should be carried out in all such cases. The final decision as to the surgical method to be chosen is made only after laparotomy or, actually, very often only after mobilization of the growth has been accomplished.

The abdominal portion of a low segmental resection and anastomosis should be performed just like that of a combined abdominoperineal resection. If this cannot be accomplished so that sufficient mobile colon is left to enable one to perform an end-to-end anastomosis without tension, segmental resection definitely should not be performed and, in my opinion, the case falls into the group in which combined abdominoperineal resection should be carried out. In some instances I have performed segmental resection and have started to make the anastomosis when the pathologist's report has prompted me to change my opinion regarding the technic to be used, and I have shifted to a combined abdominoperineal resection. This too can be accomplished without too much difficulty.

Despite the written and spoken word on the subject of colostomy, if the anus, with proper control, can be kept without sacrifice of the life or longevity of the patient, I want to perform an operation that does not sacrifice it.

THE SURGICAL TREATMENT OF PEPTIC ULCER*

A Comparison of the Results of Gastro-enterostomy, Gastric Resection and Vagotomy at the Duke Hospital

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RE-EVALUATION OF SURGICAL PROCEDURES used in the treatment of peptic ulcer has been stimulated by the introduction of vagotomy by Dragstedt¹. While final appraisal of the results of vagotomy is not yet possible, enough experience with this operation has accumulated to enable a comparison to be made between its results and those of previously accepted surgical procedures. It is our purpose to analyse the results in the surgical treatment of peptic ulcer at the Duke Hospital during the past eight years and to attempt to evaluate the place which vagotomy may hold along with gastro-enterostomy and gastric resection in the surgical management of this condition.

In the eight years prior to January 1, 1947, 265 patients with gastric or duodenal ulcer were operated upon at the Duke Hospital. Sixty-eight of these had had a gastro-enterostomy, 123 gastric resection and 77 vagotomy †

GASTRO-ENTEROSTOMY

Patients selected for gastro-enterostomy were usually in the older age group with symptoms of gastric retention. Although 75% of these patients were over 45 years of age there were three between 20 and 30 and twelve in the age group 30 to 40. All had duodenal ulcers except one in whom a large gastric ulcer with posterior perforation was misdiagnosed as an inoperable carcinoma. All had obstruction at the pylorus with from 25% to 100% retention of barium at the end of six hours.

The operations were done by 11 members of the resident and visiting staff. Fifty-one were posterior and 17 anterior anastomoses. There were three non-fatal complications, two from pneumonia and one wound infection. Thirteen, or 19%, had malfunctioning stomas, but in ten of these symptoms subsided after continuous syphon drainage of the stomach through an intra-nasal catheter. Three, or 4.4%, were relieved only by a secondary operation.* The incidence of malfunctioning stomas after anterior and posterior anastomoses was the same.

There were five hospital deaths, giving an operative mortality of 7.3%.

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Thursday, December 11, 1947.

† Three had gastric resections followed in from 3 to 5 years by vagotomy for marginal ulcer. They are included in both groups.

** In one an enterostomy was performed between proximal and distal jejunal loops. In another a plastic procedure was done between the two loops of jejunum similar to a Finney pyloroplasty. In the third patient in whom the anastomosis had been done over a Wagensteen clamp the stomach had not been opened at the time of the original operation and it was necessary to take the anastomosis down and complete the gastro-enterostomy.

One of these was from an intra-intestinal hemorrhage, presumably from the original ulcer or the suture line on the seventh day, and is the only death directly attributable to the operation. The other four deaths were caused by pulmonary embolus, coronary occlusion, cardiac failure and uremia, one each.

Of the 63 patients discharged 54 have been followed. Forty-eight (88.8%) have been entirely relieved of digestive symptoms, four having died of unrelated conditions. Three (5.6%) have had symptoms of recurrence, one having died of a gastro-intestinal hemorrhage. Three others have multiple complaints and are recognized as having a psychoneurosis, one being a morphine addict. None of the latter three have evidence of recurrence of their ulcer.

GASTRIC RESECTION

When medical measures failed gastric resection has been the operation of choice for patients whose ulcer pain was unrelieved, for those with uncontrollable bleeding (Reference to bibliography) and for those in whom the possibility of malignancy existed. These were usually in patients of the younger age group, although one-third of the group with duodenal ulcer who had resections done were over the age of 50.

These operations were performed by 11 residents and four members of the senior staff. All had an end-to-side anastomosis between the stomach and jejunum, 78 being anterior and 45 posterior to the colon.[†] The location of

TABLE I
Location of Ulcer in Patients with Gastric Resection

Duodenum	83
Stomach	31
Marginal	5
Stomach & Duodenal	4
Total	123

the ulcer and indication for operation in patients with resection is shown in Tables I and II.

Malfunctioning stomas developed in 18 or 14% of the cases but in 14 symptoms subsided with stomach drainage through an intranasal tube. Four patients required reoperation and were relieved by a plastic type of entero-anastomosis at the stoma site. Other non-fatal complications are shown in Table III.

Hospital deaths occurred in 10 of the 123 cases with resection and in an

[†]Additional procedures included disconnecting a gastro-enterostomy and resecting a marginal ulcer in four cases, taking down a gastrocolic fistula once, resecting the head of the pancreas with choledochoduodenostomy on a mistaken diagnosis of carcinoma of head of pancreas once, reconstruction or implanting the common duct into the duodenum twice (in one case where it was damaged and in another case where the ulcer involved the papilla of Vater), cholecystectomy once, and repair of diaphragmatic hernia once.

eleventh patient several months after discharge as the result of an operative error, giving an operative mortality of 89%. Three of these deaths occurred in patients who were operated upon as emergencies because of acute hemorrhage. In elective operations there were 8 deaths in 120 cases giving an operative mortality of 6.6%. Of these 8 deaths five occurred because of damage to structures in and about the duodenal stump, two were the result of pulmonary embolism and one was a cardiac death in a patient with rheumatic heart disease. Five of the deaths were directly attributed to the operative procedure, two as a result of duodenal or pancreatic duct leaks into the peritoneal cavity, two from common duct injuries and one presumably followed an injury to the hepatic artery.

Of the 112 patients who survived resection, 100 or 89.2% have been followed. Eighty-four of these (84.0%) have been entirely relieved of digestive symptoms, seven having died of unrelated conditions. Five (5.0%) have had recurrences, among whom two have died of their disease, both following reoperations elsewhere, one for perforation and one following total gastrectomy. The other three patients with recurrences had vagotomies in this clinic. One of these has been entirely well following vagotomy, another, though relieved of his ulcer symptoms is incapacitated by the post-vagotomy syndrome characterized by diarrhea, intestinal cramps, weakness and failure to gain weight. The third continues to have mild, atypical ulcer-like symptoms although no ulcer can be demonstrated by roentgen-ray or gastroscopy.

TABLE II

Indication for operation in Patients with Gastric Resection

Unrelieved Pain	28
Pain and Obstruction	43
Unhealed Gastric Ulcer	31
Uncontrolled Hemorrhage	16
Marginal Ulcer	5
Total	123

Eleven patients, in addition, continue to have gastro-intestinal complaints although their original symptoms have been largely relieved and there is no evidence of a recurrence of their ulcer. Two of these have mild, atypical ulcer-like symptoms, three have multiple complaints and are recognized as being neurotic while six have symptoms of the post-gastrectomy syndrome. These latter symptoms include fullness after meals, a tendency to regurgitate food after eating, nervousness, weakness, dizziness and inability to regain strength and weight.

VAGOTOMY

Grimson and his co-workers³ have reported in detail the first 57 of the 77 patients treated by vagotomy in the past three years in this clinic. All were

TABLE III
Non-fatal Complications Following Gastric Resection

Pneumonia	. . 6	Lung Abscess	1
Wound Disruption	5	Spinal Anesthesia Reaction	1
Atelectasis	. 2	Parotitis	1
GI Hemorrhage	2	Wound Infection	1
Pulm Tbc	1	Duodenal Fistula	1

TABLE IV —Comparative Results Following Gastro-enterostomy, Gastric Resection and Vagotomy for Peptic Ulcer

RESULTS									
	No Crises	Non-fatal Comp %	Gastric Retention %	Op for Retention %	Mort %	No Recurrence—Still Complain			
						Well %	Recur %	Atypical ulcer-like pain %	
								Multiple Comp %	Post-op Syndrome %
G E	68	4.4	19.1	4.4	7.3	88.8	5.6	0.0	
RES	123	17.0	14.6	3.2	6.6	84.0	5.0	0.0	
VAG	77	42.0	36.0	14.3	1.3	80.5	2.6	6.0	
							0.0	7.8	

transthoracic vagotomies There were 40 duodenal, 10 stomal and 7 gastric ulcers in the series Gastro-enterostomy was also performed in 12 of the cases at the time of vagotomy

Non-fatal complications in 13, or 42%, of the first 31⁴ of these cases included pneumonia in 5, pleural effusion sufficient to shift the mediastinum in 3 and atelectasis in 5 One patient in the series of 77 cases died 17 days following a combined vagotomy and pyloroplasty due to "rupture of the stomach after acute gastric dilatation and later a terminal massive hemorrhage from a duodenal ulcer"³ (mortality 13%)

Of the 77 patients⁵ 62, or 80.5% have had good results Two have had persistent ulcers both of which have been demonstrated at operation, at which time subtotal gastric resection was performed in this clinic Seven others have mild or atypical ulcer-like pain although roentgen-ray examination has not demonstrated a recurrence A little more than half of the patients in the entire group have had temporary, intermittent or moderately severe diarrhea Four of these have had severe diarrhea and one died two years following vagotomy of this condition Symptoms of retention of food in the stomach have been considered of major importance in 28 or 36% of the cases Pyloroplasty or gastro-enterostomy has been necessary as a secondary operation to relieve major symptoms of retention in 14.3% of all these vagotomized patients

DISCUSSION

None of the surgical procedures used in the treatment of peptic ulcer is ideal (Table IV)

Gastro-enterostomy alone is an entirely satisfactory procedure in the older patient with duodenal ulcer whose major symptom is from obstruction When the indications for its use are rigidly confined to this group of patients, we would consider it the procedure of choice⁶ and see no need to discard it in favor of gastric resection in all cases^{7, 8} Vagotomy alone or in combination has no place in this group of patients

Malfunctioning stomas have been a very real source of trouble with us as with others⁹ following gastro-enterostomy and gastric resection Why the stoma should not function properly in all cases is perplexing Kinking or adhesions about the anastomosis, edema from hypoproteinemia, or pressure from a thick omentum or colon may be the cause in some cases However, we have seen stomas function poorly when no adequate cause could be demonstrated In the few cases which do not subside with drainage through an intra-nasal catheter a plastic procedure similar to a Finney pyloroplasty between the proximal and distal loop of jejunum at their attachment to the stomach¹⁰ seems to be the best procedure In more than 300 cases Allen¹¹ has used successfully a proximal jejunostomy tube whose tip lies in the stomach to prevent this condition In many cases he also uses a jejunostomy tube for feeding¹² We have had no experience with these procedures but

have used, in occasional cases, tubes passed through a gastrostomy opening and extending into the stomach or jejunum or both for the same purpose

When medical measures fail, gastric resection is the procedure of choice in patients with resectable gastric ulcers and also in those with acute hemorrhage. Vagotomy has no place in either of these conditions. The possibility of carcinoma in the gastric ulcer which does not heal promptly is so great as to preclude any surgical procedure short of resection. In the presence of continued bleeding from a peptic ulcer the only satisfactory measure is a direct approach to the ulcer. In our experience this must be a resection.

There then remains a large group of ulcers, all in the duodenum, with pain which fails to respond to medical measures. They are usually in the younger age group, have high gastric acidity with or without obstruction and usually give a history of one or more hemorrhages or of perforation in the past.

Gastric resection in this group will be followed by a perfectly satisfactory result in about 85% of the cases. The operative procedure, however, may be difficult when an active ulcer with posterior penetration has attached itself to the pancreas or portal triad. Five of our eight deaths in elective resections were caused by leakage at the duodenal stump or damage to adjacent structures. This experience has influenced our decision to "exclude" thirty-five percent of duodenal ulcers when resection is done. This is in contrast to the experience of many^{13, 14, 15, 16} who prefer to remove the ulcer in all except a very small percentage of cases.

In our 31 cases in which the ulcer was not removed the duodenum was inverted above the ulcer in 8 cases, while in 23 the pyloric antrum was divided 6 to 8 cm. above the pylorus. In 12 of the latter cases, the antral mucosa was removed and in 11 of the earlier cases it was left in place. No difficulty with leakage of the closure was encountered in any of these cases. It has been our practice to invert the antral stump though Wangensteen¹⁷ has described a method of closure by apposition.

At follow-up only one in the group of 23 antral exclusions had a recurrent ulcer. The mucus membrane had been left in his pyloric stump. At reoperation the pyloric antrum and more of the stomach were resected. Subsequently he developed another stomal ulcer and died in another hospital following total gastrectomy. The universal opinion of those using antral exclusions^{17, 18, 19, 20, 21} is that the antral mucosa should be removed in all cases, and such is our present practice. The incidence of recurrence of ulcers following antral exclusion in our series is less than that in the group of resections as a whole. This is in keeping with the experience of Allen and Welch²² (1946) and Wangensteen²⁸ (1947). The latter author reports no stomal ulcers following antral exclusions in a series of just under 100 cases.

The post gastrectomy syndrome characterized by eructations, fullness after meals, weakness, dizziness, inability to gain weight or strength and sometimes accompanied by anemia has been reported in from 6% to 29%

of cases following subtotal gastrectomy^{24, 25} It has been attributed to precipitous emptying of the stomach (dumping syndrome) or to abnormal sugar absorption²⁶

Vagotomy alone, while successful in relieving the pain of peptic ulcers in a high proportion of cases, is followed by such a high incidence of unpleasant side effects that it is doubtful if the procedure ever should be used alone The 36% incidence of gastric retention of which one in three in this clinic has to have a secondary operation for drainage of a large dilated stomach is a serious complication and should lead to the abandonment of this procedure unless it be combined with gastro-enterostomy Additional side effects include intestinal cramps, diarrhea and failure to gain weight and strength and occur in about the same ratio as the gastrectomy syndrome which follows gastrectomy

Vagotomy may have a very real place when combined with pyloroplasty or gastro-enterostomy in the treatment of refractory duodenal ulcers in the younger age group However, because each operation has its own group of complications, it would seem unwise to combine the two routinely and to add the complications of one procedure to those of the other This combination of operations is frequently used by Dragstedt and is the routine practice of Gimson in our clinic at the present time Their carefully studied results should be awaited before the combined procedure is generally adopted Until then we feel that vagotomy should be reserved for the patient with marginal or recurrent ulcer following gastric resection, or gastro-enterostomy Vagotomy has no place in the treatment of resectable gastric ulcers or of duodenal ulcers with uncontrollable hemorrhage or pyloric obstruction

SUMMARY

None of the surgical procedures currently employed for peptic ulcer gives uniformly satisfactory results

Gastro-enterostomy has given the highest incidence of success in our experience (88.8%) but is applicable only in a rigidly selected group of patients in the older age group with relatively inactive ulcers and a high degree of pyloric obstruction

Gastric resection is the procedure of choice in patients whose ulcer gives intractable pain, in those with uncontrollable hemorrhage and in those with gastric ulcer when the ulcer does not heal promptly under a medical regimen Results are satisfactory in 84% of our cases Five percent have had recurrent ulcers, another 5% have multiple complaints without recurrence and 6% have symptoms of the postgastrectomy syndrome

Vagotomy carries a low operative mortality Thus far it is followed by definite evidence of recurrence in only 2.6% of cases although an additional 9% complain of mild or atypical ulcer-like pain without roentgen-ray evidence of reactivation of the ulcer The high incidence of major symptoms of gastric retention (36%) of which one in three must have a secondary operation for

stomach drainage contraindicates its use unless combined with pyloroplasty or gastro-enterostomy. Additional unpleasant side effects which include intestinal cramps, diarrhea and failure to gain weight or strength occur in an appreciable group following vagotomy (78%).

Vagotomy routinely combined with pyloroplasty or gastro-enterostomy may hold definite promise in the treatment of active duodenal ulcers with intractable symptoms. Until carefully studied results of this combination of procedures have shown otherwise it seems unwise to combine the two and add the complications of one procedure to those of the other.

The greatest indication for vagotomy in our experience has been in the management of marginal or recurrent ulcers following gastric resection. Vagotomy has no place in the treatment of gastric ulcers, actively bleeding ulcers, or inactive ulcers with pyloric obstruction.

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DISCUSSION—DR LON GROVE, Atlanta, Ga I have enjoyed Dr Gardner's paper The series of cases I wish to report represents what might be expected from gastrectomy today in a good general hospital, even though there is no organized department of gastroenterology

While we have done 168 consecutive gastrectomies, only 150 cases have been tabulated, the remaining 18 were done after the following slides were made, It is only fair to state that these were all private patients and with two exceptions were done at Emory University Hospital, and most received private duty nursing

Slide No 1 shows the 150 cases with 102 duodenal ulcers, 41 gastric and seven marginal ulcers The average duration of symptoms was 13 years It is our policy today to operate on all gastric ulcers, while only the complicated duodenal ulcers are believed to be surgical When massive hemorrhage occurs in the older age group, it is now our policy to institute surgery as soon as blood loss can be replaced, provided a previous diagnosis has been made The younger age group is still being treated conservatively

Slide No 2 shows the various technics Both the Poyla and the Hoffmeister technics have been employed, but we prefer the antcolic Hoffmeister method, removing two-thirds to three-fourths of the stomach, and when at all possible we are definitely committed to removing the ulcer even at considerable effort When this has not been feasible, we have employed the Bancroft, modification of the Finster exclusion method We are now using a shorter jejunal loop than previously We have found that if the stomach is completely free from the pancreas and the transverse colon is placed high behind the stomach, a proximal loop of not more than 16 to 20 cm will be ample This technic was adopted after a very unusual complication which occurred in an elderly woman Five weeks following gastrectomy obstruction occurred, and upon exploration we found that the proximal limb of the jejunum loop, which was too long, had herniated between the pancreas and the colon, causing a high obstruction Fortunately she recovered, but her convalescence was stormy

Slide No 3 shows the complications Pneumonia 3, atelectasis, 4, phlebitis, 2, evisceration, 1, deaths, 1, mortality rate, 66 per cent These were no non-functioning stomas that required subsequent surgery for relief, there were no leaking duodenal

stumps, no supplementary jejunostomies and no two-stage gastrectomies. While it is too early for a final report, there has been only one marginal ulcer complication. This patient has had a second resection and is now free of symptoms.

DR FREDERIC W. BANCROFT, New York. I should like to say a word about the modified Devine operation for pyloric exclusion with excision of the mucosa of the antrum, which I reported before this Association in 1931.¹

Throughout the years since I reported this series, I have operated upon quite a number of patients with excellent results, with the exception of one case which bled postoperatively and had to have the duodenal stump resected. Where the ulcer is low on the duodenum and one is afraid of the possibility of duodenal leakage postoperatively, I feel that this operation is well worth considering.

Since my report in 1931, I have modified the procedure by resecting the median portion of the stomach, leaving enough antrum so that the mucosa can be coned out and the stump closed without tension and the stomach can be resected to any extent that I feel is necessary. This does not complicate the procedure and, as you know, the middle portion is always easy to resect.

I should also like to say something about the study on vagotomy that is being carried out at the Veterans Hospital in New York. At a conference with Dr. Whipple, Dr. St. John, the Attending and the Residents we decided that we would do 50 transthoracic vagotomies in order to determine the actual benefit of the Dragstedt operation. The patients are selected by staff vote and are cases of pain with or without bleeding, but without gastric retention. We have felt that we have opportunity for unlimited follow-up. The night secretions are taken on all these patients and, if they are high and if the Hollander test shows a high acid, and if there is no gastric retention after six hours, we have felt that this is a sufficient indication. We have felt that it is inadvisable to do the subdiaphragmatic vagotomy with gastroenterostomy because we know that it took us ten years to find out the evils of gastroenterostomy without vagotomy. Therefore we have done the trans-thoracic vagotomy because we do not like to complicate the picture. We have felt that it might be possible that we might have to do a second operation if retention became accentuated after this procedure. We have also used it in cases of gastrojejunal ulcer.

Up to August, 1947, we operated on 19 of these cases. Of this group, 15 are reported as good, three fair and one failure. Our follow-ups since August have not shown any change in this analysis. Since August, 1947, 15 additional cases have been operated on. There has been one fair result because the patient had mild symptoms of pain after meals, and two of these cases have been classified as failures. One had to have a gastroenterostomy and the other, a subtotal resection. There have been a few minor chest complications which were largely due to fluid in the chest but which were readily relieved by aspiration. Our present feeling is one of mild skepticism because it is not a cure-all operation. Diarrhea has not been a noticeable postoperative finding in our series. There have been no deaths. We feel that this procedure is valuable because of its low mortality in carefully selected cases. It may be only a first stage, but certainly 80 per cent will be relieved without further operative procedure.

Most of our patients are veterans of World War II, young men, and we do not want to submit them to a subtotal gastric resection unless it proves necessary.

DR DERYL HART, Durham, N. C. (closing). I will briefly re-emphasize some of my personal opinions as crystallized by this study.

1. Gastroenterostomy still has a definite place in gastric surgery, in certain well-selected cases.

2. Gastric resection has given satisfactory results in a relatively high percentage of cases, with few marginal ulcers.

3. The greatest operative risk lies in resection of duodenal ulcers densely adherent

* A Modification of the Devine Operation of Pyloric Exclusion for Duodenal Ulcer, *Am J Surg*, 223, 1932.

to or ulcerated into the pancreas, particularly when located some distance below the pylorus

4 When the ulcer has eroded the pancreas, and is resected, it is safest to insert a drain down to this area to provide an outlet for pancreatic secretion in case a duct has been eroded

5 In this series, the results following exclusion operations have been as good as following resections. Since such an operation with removal of the antral mucosa avoids all the special risks associated with resections of perforated or adherent duodenal ulcers in proximity to the bile ducts, it probably should be used more often. This is particularly true for those operators who do some stomach surgery, but who are less experienced in handling these complicated and difficult situations. Also, if there is any indication to do so, subsequent removal of the duodenal and gastric stump following healing of the ulcer is usually relatively easy.

6 Subtotal gastric resection is a mutilating operation, at times followed by symptoms of so-called "dumping syndrome", and at times by inability of the patient to regain his lost weight. However, we must not lose sight of the fact that denervation may be even more mutilating than resection insofar as function is concerned, and the complications following vagotomy have been higher than following other types of operative treatment for ulcer.

7 The immediate mortality following vagotomy is definitely lower than following resection. However, with the trend toward some type of operation to drain the paralyzed stomach in every patient having a vagotomy, this lower mortality for vagotomy may change.

In conclusion, we would say that we are favorably impressed with the percentage of excellent results following resections or exclusion types of operations, and in certain well-selected cases, following gastroenterostomy. Vagotomy is still in the experimental stage, and we feel we are not justified in performing such an operation without explaining this to the patient, and then only if the patient and the surgeon are willing to carry out careful postoperative studies at intervals for an indefinite period of time, in order to evaluate the procedure and determine its eventual place in the treatment of ulcer.

THE SURGICAL TREATMENT OF OBSTRUCTIVE LESIONS OF THE ESOPHAGUS*

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With the comparatively recent developments in thoracic surgery, many lesions of the esophagus which formerly received only palliation by means of a gastrostomy are now subjected to direct surgical attack. No doubt, there will always be a place for an artificial epi-thoracic esophagus. Many ingenious methods of constructing such an esophagus have been devised^{1, 2, 3, 4, 5, 6, 7, 8}. Those who advocate these procedures do so on the grounds that, although multiple operations are necessary and morbidity is sometimes encountered in leakage at the anastomoses, they are safer than those methods in which the jejunum⁹ or stomach^{10,11} is brought up into the chest, and anastomosed to the proximal esophageal segment. Anastomosis of the stomach and esophagus within the chest may, in some instances, be hazardous, technically difficult, and prolonged. However, these hazards and difficulties are being overcome and good results from the latter procedure are being reported in increasing numbers^{9, 10}. Restoration of normal continuity of the digestive tract is desired whenever any portion is removed or obstructed. If this can be achieved, it is preferable to an esophageal fistula, an artificial esophagus, a gastrostomy, an ileostomy, or a colostomy. Admitting the occasional necessity for the construction of an epi-thoracic esophagus, as was shown in a recent paper by Van Prohaska and Sloan,⁶ the advantages of an intrathoracic esophagus are obvious.

In this paper I wish to report some experiences in the surgical treatment of achalasia of the esophagus, carcinoma of the cardiac end of the stomach, and cicatricial stenosis of the esophagus at the terminal, middle third, upper third, and cervical levels. Several advanced carcinomas of the esophagus have been observed, but none were operable, and palliative gastrostomies were necessary.

ACHALASIA

It is generally agreed that all patients with cardiospasm or achalasia of the esophagus should be given a fair trial with dilatations, as many will be relieved of their distressing symptoms by this procedure^{12, 13}. In those cases in which dilatation fails, surgical intervention will be necessary to prevent serious malnutrition and even starvation. In addition to dysphagia, these patients complain of severe pain and "heart-burn" from esophagitis. This is due to actual digestion of the esophageal mucosa from the fermentation of food retained in the dilated esophagus. Avitaminosis is a contributing factor, as Fisher¹⁴ has demonstrated by esophagoscopy in patients suffering from pellagra.

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Thursday, December 11, 1947.

The etiology of cardiospasm is not well understood. Many methods have been employed in efforts to correct the resulting obstruction. Ochsner and DeBakey,¹⁵ Bell,¹⁶ Grimson,¹⁷ and others have described in detail these different technics, all leading up to the currently popular and very satisfactory

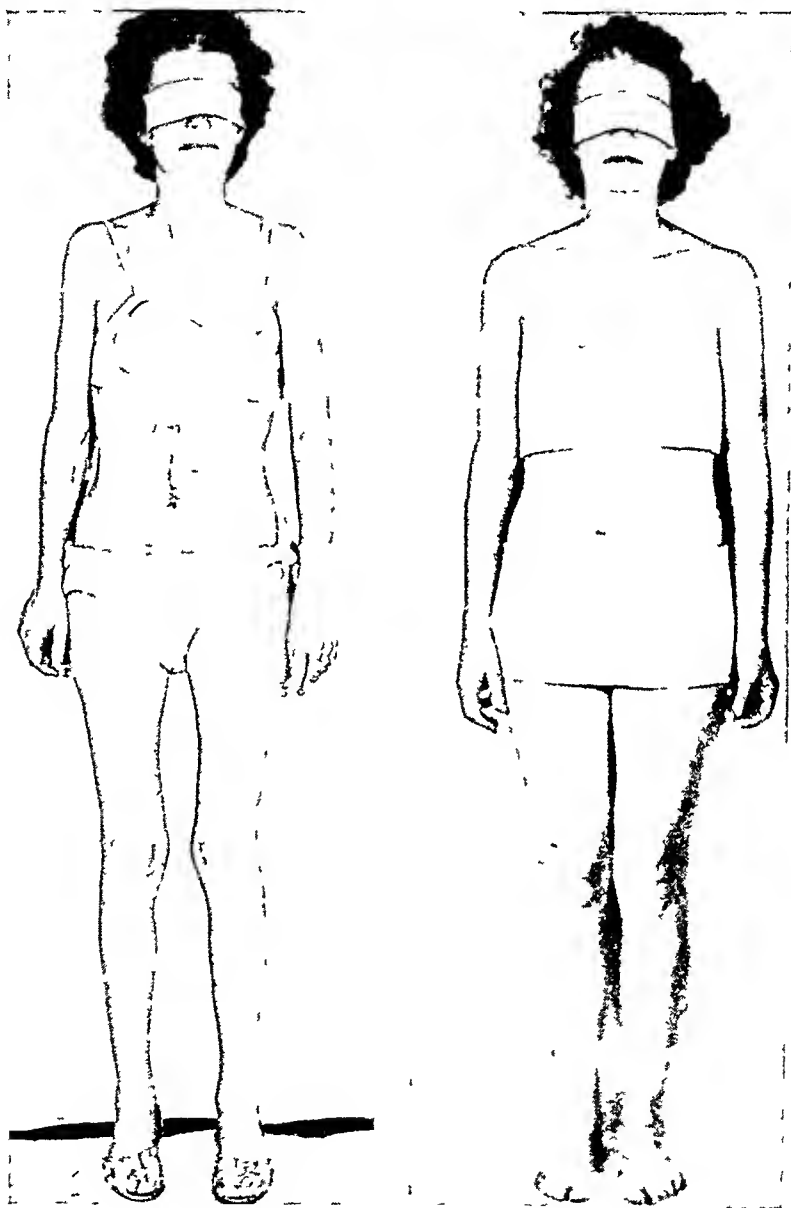


FIG 1

FIG 2

CASE 3—Achalasia of the esophagus

FIG 1—Photograph 10th postoperative day (July 1947) showing extreme emaciation. Patient's weight 93 lbs

CASE 3 FIG 2—Photograph October 1947. Patient's weight 117 lbs

trans-abdominal esophago-gastrostomy based on the principle of the Finney pyloroplasty. This procedure has been well illustrated in a recent paper by Bell¹⁶. We have employed the method successfully in four cases, three of

which were true achalasias, the other being a case of cicatricial stenosis at the terminal end of the esophagus of undetermined etiology

Case 1 History—Jefferson-Hillman Hospital No 24276 C G, colored female, age 18, had been a dispensary patient for several weeks, with a history of dysphagia of three years' duration. A diagnosis of achalasia of the esophagus had been made by roentgen-ray and esophagoscopy examinations. Repeated dilatations gave only temporary relief.

She was admitted to the hospital on August 14, 1946. At that time her weight was 95 lbs.

On August 19, 1946, a trans-abdominal esophagogastrostomy was performed. The postoperative course was smooth and when discharged on September 10, she was eating solid food without difficulty. She returned to the hospital for a check up in October,

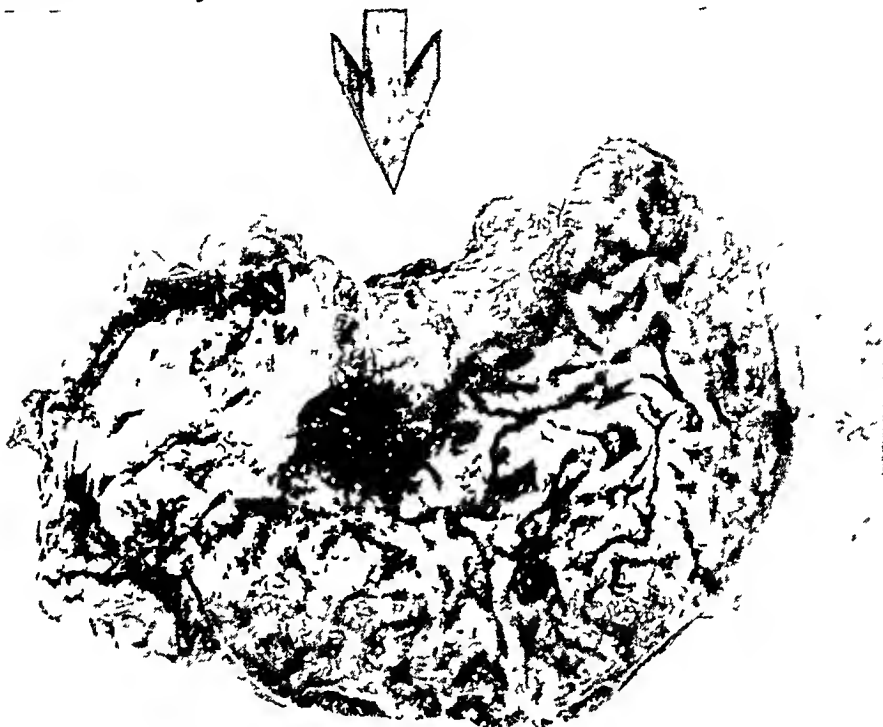


FIG 3

CASE 6—Carcinoma of cardia of stomach

FIG 3—Specimen showing tumor and ulcer crater. Arrow indicates esophago-gastric junction.

1947. A barium study of the esophagus showed no obstruction, she weighed 130 lbs, and had no complaints.

Case 2 History—Jefferson-Hillman Hospital No 34645 S M, a white male, age 65, was admitted to the hospital on January 11, 1947. He had suffered from dysphagia for the past three years. During this period he had been unable to eat solid food. His weight was 117 lbs. Heart-burn was a constant complaint. A diagnosis of achalasia was made by roentgen-ray and esophagoscopy. Dilatations gave no relief. On February 5, 1947, a trans-abdominal esophagogastrostomy was performed. His convalescence was smooth and he was discharged on the 14th postoperative day eating solid food. Post-operative roentgen-ray studies showed that the barium passed readily into the stomach. He has been followed at frequent intervals in the dispensary, weighed 133 lbs in April, 1947, and was having no difficulty eating any kind of food.

Case 3 History—St Vincent's Hospital, No N526 E M C, white, female, married, age 38, was admitted June 29, 1947, with a history of dysphagia increasing in severity for the past two years. For three weeks before admission she was only able to swallow liquids. On admission her weight was 93 lbs. Prior to the beginning of her

illness, her average weight had been 120 lbs. Heart-burn was a constant symptom. Dilatations of the esophagus had given no relief. A diagnosis of achalasia was made by roentgen-ray and esophagoscopy examinations. On July 2, 1947, a trans-abdominal esophago-gastrostomy was performed. Her convalescence was smooth and she was discharged from the hospital July 13, 1947, swallowing without difficulty. She returned on October 28, 1947, for check up. Her dysphagia was completely relieved and she weighed 117 lbs.

Case 4 History—St Vincent's Hospital, No M9956 S B R., white, female, married, age 44, was admitted to the hospital on May 22, 1947, with dysphagia of five years' duration. Dilatations at frequent intervals before admission, performed elsewhere, had not helped her. The dysphagia had been severe since April, 1947. She



FIG 4

CASE 6 FIG 4—Postoperative X-ray

weighed 110 lbs at time of admission. She was able to swallow liquids, but no solid food. "Heart-burn" and regurgitation of saliva were constant symptoms. A diagnosis of stricture of the terminal esophagus was made by roentgen-ray and esophagoscopy. The etiology of the condition was unknown and there was no history of the ingestion of any escharotic agents. Since the strictured area was in the terminal esophagus, we elected

to try the achalasia operation, reserving the more formidable trans-thoracic esophageal resection and intra-thoracic esophago-gastrostomy for a later date in case an adequate lumen was not obtained. She was operated upon May 24, 1947, by the trans-abdominal route. The strictured area was incised longitudinally and an esophago-gastrostomy performed as for correction of achalasia. Her postoperative course was smooth. The lumen of the esophagus is adequate, and she can eat whatever she wishes, but must masticate her food well. She has been followed at frequent intervals and weighs 140 lbs.

Case 5 History—Jefferson-Hillman Hospital No 38603 R M, colored, male, age 32, was admitted on January 17, 1947, with complaint of dysphagia and substernal burning for a year. He had lost 50 lbs in weight. A diagnosis of achalasia of the esophagus was made by roentgen-ray and esophagoscopy. The patient had a definite psychosis,

due apparently to ignorance, superstition, and malnutrition, and committed suicide by jumping from a third story window while undergoing treatment preparatory to operation. An autopsy was obtained, and photographs show the conditions found in the diseased esophagus.



FIG 5

CASE 6 FIG 5—Showing healed incision
9th left interspace

Case 6 History—St Vincent's Hospital, No N1894, G B, white, male, married, age 40, was first seen on September 10, 1947, complaining of dysphagia of three months' duration. He gave a history of peptic ulcer of several years' duration, and had been discharged from the regular Army on account of this disability. He was in good general condition otherwise, and weighed 180 lbs. He underwent esophagoscopy on September 10, and a specimen, positive for carcinoma of the stomach, was taken from a tumor mass projecting into the lumen of the esophagus at the esophago-gastric junction. On September 20, through a left trans-thoracic approach, the distal end of the esophagus and the upper two thirds of the stomach were removed. Intra-thoracic esophago-gastrostomy was performed. The postoperative course was uneventful and he left the hospital October 9, swallowing without difficulty, and has remained well.

The resected portion of stomach revealed a large ulcerated carcinoma of the cardia. Sections of the lower esophagus showed that the growth had not invaded this organ.

RESECTION OF THE ESOPHAGUS

In reviewing the literature, there seems to be unanimity of opinion that lesions of the lower third of the esophagus are best treated by resection and intra-thoracic esophago-gastrostomy^{18, 20, 21, 23, 24}. However, in dealing with

CARCINOMA OF THE CARDIAC END OF THE STOMACH

Due to the greater ease of exposure, the trans-thoracic approach to lesions high in the stomach is being extensively employed^{18, 19, 20, 22, 23}.

A case of carcinoma of the cardia causing obstruction at the esophageal orifice was successfully operated upon using this approach.

lesions of the upper two-thirds, there are two schools of thought. One favors the performance of the plastic type of epi-thoracic esophagus^{1, 2, 3, 4, 5, 6, 23}. The other advocates mobilization of the stomach or jejunum,^{9, 10, 11, 25} with the performance of an intra-thoracic esophago-jejunostomy or gastrostomy, which may be carried out as high as the suprasternal notch. We have performed three esophago-gastrostomies according to the technic of Sweet^{10, 25}.

Case 7 History—Jefferson-Hillman Hospital No 25219 G D, colored, female, age 28, was admitted to the hospital on November 11, 1946. In June, 1946, she had swallowed



FIG 6

CASE 10—Lye stricture of esophagus high in the cervical portion
FIG 6—X-ray showing level of stricture

lye. She had several admissions to the hospital for dilatations of the resulting stricture. These dilatations gave only temporary relief. Her weight was 113 lbs. The stricture lay at the level of the arch of the aorta. On November 20, 1946, a sub-total esophagectomy with high intrathoracic esophago-gastrostomy following the method of Sweet was performed. In her postoperative course, fluid accumulated in the pleural cavities. This

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was aspirated and both lungs expanded. Otherwise, her postoperative course was smooth. She was discharged December 14, 1946, swallowing solid foods without difficulty. She was readmitted to the hospital in October, 1947, for a check up. She weighed 120 lbs, and was swallowing without difficulty. She ate a full diet and worked every day. Roentgen-ray studies showed a well functioning anastomosis.

Case 8 History—St Vincent's Hospital, No N2142 W M H, white, female, married, age 41, was admitted to the hospital on October 6, 1947. When she was two years of age she swallowed lye, and an extensive stenosis of the esophagus resulted. This began at the level of the aortic arch and extended downward, involving the lower two-thirds of the organ. Dilatations had been carried out from time to time, but none for the preceding four years. She was said to have weighed 130 lbs five years ago, but at the time of admission her weight was 97 lbs.

On October 11 a sub-total esophagectomy with high intra-thoracic esophago-



FIG 7
CASE 10 FIG 7—Postoperative X-ray showing barium passing freely into stomach

gastrostomy was carried out. The operation was unattended with any special technical difficulty and abundant fluid and blood replacement was employed. For two days her condition appeared quite favorable, but death took place suddenly on October 13. Autopsy showed normal progress of healing with no leakage at site of anastomosis. There was a moderate amount of sero-sanguinolent effusion in the left chest, which was to be expected, and which usually requires aspiration in cases that progress favorably. The exact cause

of death was not ascertained. My impression is that we over-estimated the ability of this debilitated patient to withstand so formidable an operation.

Case 9 History—Jefferson-Hillman Hospital, No 1956 E M, colored, male, age 4, swallowed lye in July, 1945, resulting in an esophageal stricture just below the level of the clavicle. A gastrostomy had been performed, and he had been followed in the dispensary for two years. His nutrition was only fairly well maintained on the gastrostomy feedings at home and he had several admissions to the hospital for attempts at dilatation of the stricture and for high caloric gastrostomy feedings. Due to his poor economic environment it was becoming quite a problem to obtain adequate diet for him, and unless he stayed in the hospital, malnutrition became marked.

On January 20, 1947, a sub-total esophagectomy with intra-thoracic esophago-gastrostomy at the level of the suprasternal notch was performed. While the location of this stricture was very high, there were no technical difficulties in freeing the esophagus and in making the anastomosis. The child died suddenly only 24 hours after operation. The exact cause of death was not ascertained, as an autopsy was refused.

STRICTURE OF THE CERVICAL ESOPHAGUS

A unique type of esophageal stricture is that in which the ingestion of lye or other escharotic agent causes a burn at the laryngo-esophageal junction or in the upper cervical esophagus. When dilatations of strictures in these locations are unsuccessful, relief of the obstruction is extremely difficult, since neither the stomach nor the jejunum can be brought up this high, and the cervical stump cannot be brought to the surface of the neck for anastomosis with an epi-thoracic esophagus.

We present a case of cicatricial stenosis of the upper servical esophagus corrected by longitudinal division of the stricture and reconstruction of an adequate lumen over a bougie.

Case 10 History—Jefferson-Hillman Hospital, No 40188 L N, colored, male, married, age 46, was admitted to the hospital on January 24, 1947, with a stricture high in the cervical esophagus which followed the accidental swallowing of lye four weeks previously. Attempts at dilatation were unsuccessful, and on January 31, 1947, a gastrostomy was performed. He was discharged on February 8, and was readmitted on March 12, weighing 114 lbs. He was experiencing difficulty in maintaining adequate nutrition by gastrostomy feedings. On March 26, the cervical esophagus was exposed through an incision on the left side of the neck parallel to the anterior border of the sterno-cleido-mastoid muscle. The strictured area, measuring about one inch in length was incised longitudinally, a nasal tube was passed into the esophagus through the stricture, and into the stomach, where the distal end was brought out through the gastrostomy opening. A string was attached to the lower end of the nasal tube and was pulled through the strictured area and out of the mouth. The tube was then removed and a bougie was placed within the strictured area and anchored by a string attached to each end. The wound was closed in two layers over the bougie. Gentle traction on the string gave early motion to the bougie and prevented the formation of adhesions in the divided strictured area. The wound healed per primum, and the bougie was removed. It was not possible to continue dilatations during his stay in the hospital. He was discharged on May 2, 1947, with adequate esophageal lumen and had gained in weight from 114 to 145 lbs. He has been followed at intervals and the esophageal lumen continues adequate.

SUMMARY

- 1 The surgical treatment of achalasia of the esophagus is illustrated. Cases are reported.
- 2 The transthoracic approach for resection of high gastric lesions is advocated, with presentation of a successful case.

- 3 Sub-total esophagectomy with intra-thoracic esophago-gastrostomy is advocated for obstructive lesions of the esophagus in the upper, middle and lower thirds, with report of three cases. None of these presented any technical difficulties. Unfortunately, two did not survive. One of these was perhaps too young for so formidable an undertaking. The other was probably more debilitated than was appreciated.

Regardless of the mortality in this small series, we prefer this method since larger groups are being reported with much lower death rates.

- 4 A lye stricture of the high cervical esophagus is reported which was successfully treated by external longitudinal division of the stricture and reconstruction of the lumen over a bougie.

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DISCUSSION—DR ALTON OCHSNER, New Orleans D^r R Mason has shown us beautifully what can be accomplished in otherwise intractable lesions of the esophagus. With the introduction of antibiotics, it became possible to enter the chest and operate safely, which we could not do before. There are still, however, certain difficulties. One is the fact that these patients who are chronically ill, suffering either from neoplasms or infection, are likely to have contracted blood volumes, and unless the blood volume deficiency is determined and corrected, they are not able to withstand an operation of any magnitude. The ordinary blood determinations, such as the red cell count and hemoglobin determination, are not sufficient in these patients to determine whether or not anemia is present. Unless the blood volume deficiency is corrected, not only is shock likely to occur during the operative procedure, but also healing is interfered with.

Another difficulty in esophageal surgery is the incidence of stricture at the esophageal-gastric anastomosis. Dr DeBakey and I have suggested a modification of the usually employed technic, which consists of a longitudinal incision in the esophagus, extending from the open end, thus increasing the esophageal opening. In this way the size of the opening can be greatly increased. Since we have been using this we have had no cases of stricture.

My further discussion will be limited to the organic strictures of the upper end of the esophagus. The first was in a patient aged 32 who swallowed lye at the age of two. As shown in the slide, a stricture is present in the upper portion of the thoracic esophagus in the region of the arch of the aorta. Esophageal dilation was not possible except under esophagoscopy. In order to cure this patient it was necessary to remove all the thoracic esophagus and reestablish the continuity of the digestive tract by bringing the stomach up and anastomosing it to the esophagus at the pleural apex. The next patient was one with a carcinoma of the esophagus involving the upper third of the thoracic portion which required resection of the entire esophagus, mobilization of the esophagus from behind the arch of the aorta, and anastomosing between the upper end of the esophagus and the stomach. The procedure in both these patients was tolerated well and the patients have made uneventful recoveries. These were possible, we believe, because of reestablishment of the blood volume and the use of appropriate technical procedures.

DR J E DAILEY, Houston, Texas It is with gratitude for the opportunity, and also with some trepidation, that I venture to discuss this paper. I only wish Dr Mason had had the time to go into the postoperative care of these cases more fully. I think this is most important. In the past two years we have had the opportunity to perform twelve of these operations, that is, esophagectomies and partial resections of the stomach with anastomosis. I would like to mention three points of interest in postoperative management of these cases. In the first place, since it is generally believed that the use

OBSTRUCTIVE LESIONS OF THE ESOPHAGUS

of concentrated saline solutions intravenously has the tendency to concentrate salt in the region of the trauma with resulting edema, we have felt hesitant about using saline postoperatively and during operation, thinking that such edema at the site of anastomosis might interfere with healing. The second point is that we do not make it a policy to use a Levine tube routinely. In only two cases we had difficulty with stomach dilation postoperatively, probably due to section of the vagi, and we had to use a tube. And third, we have felt that since these patients produce and swallow their own saliva, there was no necessity for withholding liquids postoperatively. So we have permitted them to have water by mouth, one ounce each hour immediately, and on the second postoperative day have added a liquid formula diet and then increased it to a soft diet by the end of a week.

DR C FRANK CHUNN, Tampa, Florida. I want to congratulate Dr. Mason on his work, his excellent results and his presentation.

Achalasia of the esophagus, in the great majority of cases, is successfully treated by one or more courses of dilation of the esophagus. However, in from 2 to 5 per cent of cases, surgical reconstruction of an esophageal lumen is necessary.

With the concept that present day methods of anesthesia, chemotherapy and blood transfusion probably render thoracotomy as safe as laparotomy, I would like to show a few slides of the trans-thoracic resection of the lesion of esophageal achalasia with a thoracic esophago-gastrostomy.

Slide No 1 shows the barium swallow shadowgram of a 55 year old white man whose dysphagia began in 1918. Multiple courses of esophageal dilation were of only temporary benefit. Since 1930 he had been unable to swallow anything except liquids, and even liquids became progressively more difficult. When seen in December, 1946, he had been unable to swallow even water for three days. X-rays and esophagoscopy examination indicated achalasia of the esophagus.

Slide No 2. After appropriate preoperative preparation, a transthoracic resection of the esophageal lesion was carried out. The stomach was mobilized, the cardia was placed into the pleural cavity and the anastomosis of the esophagus to the cardia of the stomach was done. This was accomplished by using no clamps on the esophagus and having absolutely no tension on the anastomosis. The patient was out of bed in three days and went home in eleven days.

Slide No 3. This shows the barium swallow two months postoperative, showing a very adequate anastomosis and stomach filling. He has eaten a normal diet without difficulty since soon after discharge from the hospital.

In dealing with lye strictures of the esophagus, especially since the great majority of these patients are children (however, we have treated our adult patients in the same way) we prefer to construct a Whitzel gastrostomy with the serous membrane lined tube of the gastrostomy pointing at the esophageal opening. Then by placing and maintaining a silk string through the nose, stomach, and out through the gastrostomy, we have successfully dilated all our esophageal strictures. The dilations are done in the retrograde direction by pulling increasingly large rubber bougies through the gastrostomy and esophagus. The patient swallows liquids in a day or two, takes a soft diet in a few days and, a little later, a normal diet. Weekly retrograde esophageal dilations are done until the esophagus is fully dilated, and the dilation remains. This requires between one and two years.

In our hands this method has been very satisfactory. We have been able to dilate all our cases of lye stricture of the esophagus without mortality.

Again I would like to congratulate Dr. Mason on this excellent work.

DR EDGAR W DAVIS, Washington, D C. As a visitor I greatly appreciate the privilege of the floor to discuss Dr. Mason's paper. I congratulate him on his presentation. He has shown us that surgery of the esophagus has already passed the experimental stage and has now been added to our list of acceptable surgical procedures. This field of surgery has made tremendous strides in the last few years. To emphasize this progress,

I would like to say that it has now been a little less than three years since I attended a meeting in one of our large cities. The speaker on that occasion was introduced as being a man who knew more about cardiospasm than anyone in the world. In the speaker's discussion on carcinoma of the esophagus, he stated that surgery for carcinoma of the esophagus was nothing short of euthanasia. I am sure that speaker does not maintain that idea today. We, as surgeons, realize the clinical significance of the various obstructive lesions of the esophagus, and are anxious to try to do something for these unfortunate patients, but it seems that many medical men are still reluctant to refer these patients for surgery. For this reason I feel Dr. Mason's paper would be of even greater importance if presented to a mixed group of physicians than to a group consisting of surgeons only. I would emphasize the importance of esophagoscopy examination for any patient who has difficulty in swallowing, as the diagnosis will be made much earlier and the outcome will be much more favorable. It is relatively common for patients to be referred to us with a diagnosis of cardiospasm, who have been treated for months with belladonna, atropin or other antispasmodics. This line of treatment should be strongly condemned, and more appropriate diagnostic methods should be used earlier.

I cannot agree with one of the discussors who resected a short segment of esophagus and did an esophagogastrostomy for cardiospasm. The majority of cardiospasm can be carried successfully through life by careful and adequate dilation. If, however, dilation is not successful, a transthoracic or abdominal esophagogastrostomy without resection is the procedure of choice, because the operation is much less formidable, the end results are better and the mortality rate is much lower. This same procedure has been used also with gratifying results in a benign stricture of the lower end of the esophagus which resisted all forms of dilation.

If I may diverge for a moment from the discussion on obstructive lesions of the esophagus, I might say that I was greatly impressed by the number of patients who died from postoperative pulmonary complications after gastric resection, as presented in the previous papers. These postoperative deaths from pulmonary complications were designated as deaths from pneumonia. I seriously doubt that there is any such thing as postoperative pneumonia developing within the first two to five days following an operation. In my opinion, practically all these cases begin as a postoperative atelectasis and, if unrecognized and not properly handled, may of course develop a superimposed infection which then may be designated as pneumonia. The importance of proper postoperative care for these patients cannot be overemphasized. Accumulation of pleural fluid, unless of small amount, demands thoracentesis. Postoperative atelectasis demands bronchoscopic aspiration if the obstructing plug of mucus in the bronchus cannot be removed promptly by other means.

In connection with carcinoma of the lower end of the esophagus or the upper part of the stomach, when the obstruction is complete, although the lesion may be unresectable, an anastomosis of the stomach with the esophagus above the obstruction has furnished relief for a short time to one of our patients.

DR JAMES M MASON III, Birmingham, Ala (closing). Of course blood replacement, as Dr. Ochsner emphasized, makes radical surgery possible. This is absolutely essential. Referring to Dr. Dailey's discussion of postoperative treatment, Dr. Davis pointed out that the most important step is prompt and complete re-expansion of the lung.

Whenever discussion of the use of the nasal tube for gastric suction is brought up, I refer to a paper Dr. A. O. Singleton presented before the American Surgical Association in 1942. We feel very strongly in favor of its use. Many children with lye strictures are treated successfully with dilations. Radical surgery is applied to those in which dilations are unsuccessful.

In the treatment of achalasia we prefer the transabdominal approach. The esophagus can be quite adequately mobilized from below the diaphragm, and this approach obviates the necessity of opening the pleural cavity.

PRELIMINARY REPORT ON THE USE OF TANTALUM MESH IN THE REPAIR OF VENTRAL HERNIAS*

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THE REPAIR of very large ventral hernias has always taxed the ingenuity of the surgeon. This is true not only when the defect is large, but also when the fascial structures surrounding a smaller defect are weak. A large proportion of these cases occur in very obese people. In such people the fascia surrounding the defect is often weakened by the infiltration of fat, and this militates against a successful repair by any of the ordinary methods. Fascial flaps of various sorts from the local site have been used to repair the defect. Free autogenous transplants of fascia lata have also been used. Years ago the present writer¹ introduced the use of large sheets of ox fascia lata for the repair of such defects. All of these methods have been more or less successful, but none has been uniformly so, especially in the type of case dealt with in this paper.

On March 20, 1946 when my attention was called to tantalum mesh by one of our leading surgical supply houses,[†] I welcomed the opportunity to try it out, both experimentally and clinically. The material had already been used on a limited number of cases by C R Lam,² of the Henry Ford Hospital, and by T D Throckmorton,³ of Des Moines. I, also, have now used the material in a limited number of cases both experimentally and clinically. It has not been used more widely because the supply has been very limited, for a period of time the material was not procurable at all. Recent information indicates that it is now available on the open market.

Metal filigrees, such as silver, were introduced for hernia repair many years ago, and this method has recently been reviewed by Cole.⁴ So far as I know, however, nothing similar to a screen mesh has been used before the introduction of tantalum mesh.

I have used tantalum mesh experimentally in four dogs. In each instance three to six inches of the rectus muscle on each side was resected, and the defect immediately repaired by suturing a piece of tantalum gauze to the edges of the fascia surrounding the defect, there being nothing left between the peritoneum and the subcutaneous tissue but the tantalum gauze. These animals were sacrificed from 4½ to 9½ months after operation. In each instance the defect was completely closed by the mesh, which had become

* Read before the Southern Surgical Association at Hollywood Beach, Florida, December 11, 1947.

† My attention was first directed to tantalum gauze by Dr Herbert L Davis, Director of the Department of Experimental Research for the Ethicon Suture Laboratories, of Johnson & Johnson, New Brunswick, New Jersey. During the course of some correspondence with Dr Davis, with regard to changing the solution in which ox fascia is preserved, he stated that he had been interested in the possibilities of tantalum gauze for the repair of hernias and asked if I would like to try it out. Johnson & Johnson furnished all the materials (tantalum mesh and tantalum wire) used for the experiments in this paper.

covered by a thick and tough envelope of fibrous tissue. The fibrous tissue had grown through the meshes of the gauze throughout, and could not be separated from it except by very sharp dissection (Fig 1). A firmer and more thorough-going closure of the defect can scarcely be imagined.



FIG 1 Piece of tantalum gauze removed from a dog 9½ months after operation. The meshes of the gauze have been thoroughly infiltrated with fibrous tissue and the entire piece of gauze is covered with a tough envelope of fibrous tissue.

The material has now been used clinically in five cases. All of these cases were very fat people who had very large hernias and poor tissues to deal with. The first case was a private patient operated upon at the Union Memorial Hospital. Three cases were ward patients from my service at the Sinai Hospital. One patient was operated upon on the service of Dr. Howard Kern at the Sinai Hospital, and he has kindly consented to allow me to include it in the series. In Case 4 of the series (Figs 2, 3, 4 and 5), it was impossible to close the large defect, and a piece of tantalum gauze was sutured to the edges of the defect, overlapping the edges somewhat, and leaving only the gauze between the peritoneum and the subcutaneous tissue, just as in the experimental animals. In the other cases it was possible barely to approximate the edges of the defect, and it was certain that the repair would not have held with this simple approximation. In these cases the suture line was reinforced by suturing a piece of tantalum mesh over it, well overlapping the surrounding weak fascia. In one case (Case 5), after a simple approximation of the edges of the defect, the tissues were under so much tension that the rectus sheath was split longitudinally on each side of the suture line to relieve tension, and then the suture line, and also the incisions in the rectus sheath, were covered by tantalum mesh.

The technic of using this material is shown in Figure 6. The mesh is held



FIG 2—Front view of Case 4 before operation

FIG 3—Side view of Case 4 before operation



FIG 4—Front view of Case 4 two weeks after operation

FIG 5—Side view of Case 4 two weeks after operation

in place with interrupted sutures of tantalum wire. Before placing the sutures, about $\frac{1}{4}$ inch of the edge of the mesh is turned over on itself, so that the sutures go through two thicknesses of the mesh. This makes the sutured edge stronger, and prevents the wire suture from pulling out of the mesh. The material is pliable and easy to handle. It can easily be cut with ordinary surgical scissors. Braided tantalum wire is now available on atraumatic needles, which makes the suturing of the mesh in place a much easier procedure. The braided wire is as easy to handle as silk or catgut.

The first of the patients here reported was operated upon 18 months ago,

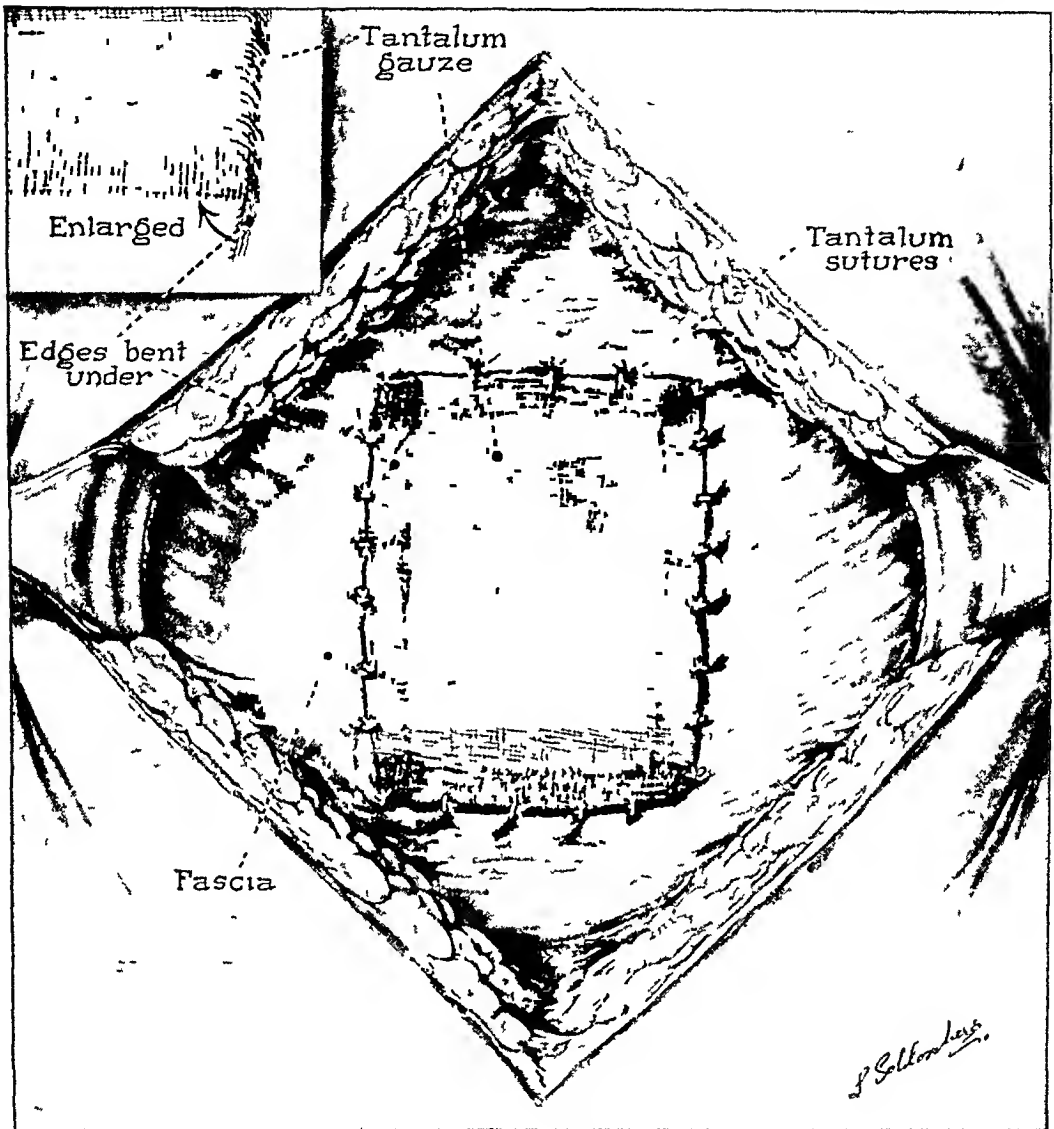


FIG 6—Technic of suturing tantalum mesh in place

and the most recent one only 2 months ago. All of these patients have recently been examined personally by me, and all so far show excellent results. Also, all of them are delighted with the excellent results obtained, so far as their personal comfort is concerned. We often overlook the fact that these patients suffer a great deal of discomfort, not only from the feeling of insecurity occasioned by the defect in the abdominal wall and the dragging down sensation associated with it, but also from nausea and other disagreeable symptoms. The second patient in the present series was so miserable that he had contemplated suicide, because a previous attempt to cure his hernia had been unsuccessful, and he felt that there was no relief from his discomfort. Life is now again a pleasure for him. The first patient in the series had had two unsuccessful attempts to repair her hernia, and she is equally delighted with the outcome.



FIG 7—X-ray of Case 5 five weeks after operation, showing the implanted piece of tantalum gauze to be intact

The appearance of the tantalum gauze by x-ray has been studied in two cases. Figures 7 and 8 show the x-rays of these two cases (Cases 2 and 5), one taken five weeks after the operation and the other 11 months after operation. It will be noted that in the case recently operated upon (Case 5—Fig 7), the mesh is intact, while in that operated upon 11 months prior to x-ray (Case 2—Fig 8) there is a good deal of fragmentation of the mesh. This fragmentation, which occurred in the second case (discussed in the preceding paragraph), has not in any way interfered with the strength of the repair. The patients, in general, are unaware of the presence of the mesh. The strength of the repair is not due to the mesh itself, but to the fibrous tissues built up through and around it, which form a very strong abdominal wall.

I have often wondered what another surgeon, subsequently doing a laparotomy on one of these patients, would think when he had encountered wire screening in the belly wall of his patient. It might be wise for the patient to tell any subsequent surgeon about the type of hernia repair he had had. The

material, however, would offer no real obstacle to a subsequent laparotomy, as it is readily cut through with scissors

COMMENT

The early results with the use of this material, both experimentally and clinically, are such as to fill this writer with enthusiasm. There have been no untoward side effects in any of the cases, except that in the first case



FIG 8—X-ray of Case 2 eleven months after operation. Note the partial fragmentation of the tantalum mesh.

operated upon there was a collection of sterile fluid in the lower end of the wound. This was aspirated and did not recur. None of the other cases had it. I believe that the collection of fluid was probably due to a dead space left at the time of operation. This should be avoided. There have been no infections in this small series, and there has been no untoward tissue reaction, either experimentally or clinically.

In operating on these cases, the tantalum mesh should be covered by skin that has enough subcutaneous tissue under it to prevent the palpation of the

mesh through the skin. Very often the subcutaneous tissue is very much thinned out over the hernia, and in places is entirely absent, the peritoneum being adherent to the skin itself. In these cases, however, there is generally enough redundant skin to permit resection back to skin that has underlying cutaneous tissue. If necessary, flaps can be mobilized by undercutting, and brought together over the implanted tantalum mesh.

CONCLUSION

A limited experience with the use of tantalum mesh in the repair of large and difficult ventral hernias leads to the belief that it will prove a most valuable material in the cure of this difficult condition.

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DISCUSSION—DR J. M. T. FINNEY, JR., Baltimore: I cannot let this go by without giving a personal word of thanks to Amos Koontz for his interest in this problem of bad herniae. His experimental work in the healing of tissues after operative repair is classic. As you all know, he has been interested for many years in repair of difficult herniae, and anyone who does surgery knows such repair can be most difficult, particularly if there have been three or four previous operations to mess things up. He gave us preserved fascia and now this mesh. The coordinating clinical work is something for which we all, as operating surgeons, should be eternally grateful. I have not used the mesh yet, but if I run into any problems like those he showed on the screen, I shall certainly be glad to have him tell me how to handle them.

DR WILLIAM H. PRIOLEAU, Charleston, S. C.: With Dr. Finney, I would like to commend Dr. Koontz for his continued pioneer work in this field. It appears that the use of tantalum mesh will prove to be a solution in the repair of a large number of ventral herniae. We are familiar with the value of alloy steel wire in the closure of grossly contaminated and even infected abdominal incisions. In such cases the wire is well tolerated by the tissues. It is seldom extruded or causes a persistency of the infection with sinus formation, as is so commonly the case with silk and cotton. It would be of interest and utmost importance to know how tantalum mesh would behave under such conditions. Would it be tolerated and serve as an effective support to the wound, or would it have to be removed? If well tolerated in the presence of infection and contamination, its field of usefulness will be greatly increased.

DR AMOS R. KOONTZ, Baltimore (closing): I want to thank both Dr. Finney and Dr. Prioleau for their discussions, and also Dr. Prioleau for his suggestion with regard to trying out tantalum gauze in infected areas. I shall certainly follow through on this when I get back.

PERINEAL HERNIA*

Report of a Case Occurring in a Male

THOMAS HARROLD

MACON, GA

EXCEPT FOR THE COMMONPLACE CYSTOCELE and rectocele and the less common enterocele which are seen in women following the trauma of childbirth, hernia through the pelvic floor in either sex is quite rare and excessively rare in the male. I wish to report a spontaneous levator or perineal hernia occurring in a man with no history of trauma.

In 1922 Chase¹ suggested the name of levator hernia and offered a simple classification of these herniae

Levator Hernia

- 1 Congenital
 - a Pudendal
 - b Perineal
 - c Mixed
- 2 Acquired
 - a Pudendal
 - b Perineal
 - c Mixed

Yeomans^{2, 3} and others have called attention to the weak spot in the perineal floor at the point of junction of the iliococcygeus and the pubococcygeus muscles. It is thought that most levator herniae break through at this point, although they may occur through any portion of the levator muscle. Having passed through the levator muscle, further descent must be either anterior or posterior to the transversus perinei muscle and thence into the subcutaneous tissue of the vulva or perineum. The anterior space in the male is filled quite solidly with the prostate and is not subjected to the various injuries and accidents of childbirth, therefore anterior levator or pudendal hernia is rare in the male and some authors state that it does not occur. The most vulnerable spot in the male perineum is posterior to the transversus muscle in the pararectal or ischio-rectal region where, even in the normal perineum, there is a surprisingly strong impulse on coughing.

Pudendal hernia is very difficult to repair but several successful cases are reported.

Considering the degree of trauma involved, perineal hernia following abdomino-perineal resection of the recto-sigmoid is surprisingly rare and constitutes a special group not considered in this paper.

In 1918 Moschowitz⁴ reported a case of perineal hernia and collected a total of 28 cases, some of doubtful authenticity, in a review of the world literature prior to that time. Only 3 cases in males were found. 1. Thomas in 1897 reported a perineal hernia which appeared suddenly in a man, aged 62,

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PERINEAL HERNIA

while he was lifting a heavy weight. It was quite large and only partially reducible. At operation a large fibromyoma was removed and the hernia successfully repaired. 2 Harrison in 1866 reported a strangulated perineal hernia in a male. The hernia was incised and a loop of gangrenous bowel was extruded spontaneously. The patient recovered but no statement is made as to the cure of the hernia. 3 Stiegele in 1869 reported the reduction of a

Muscles of the Perineum

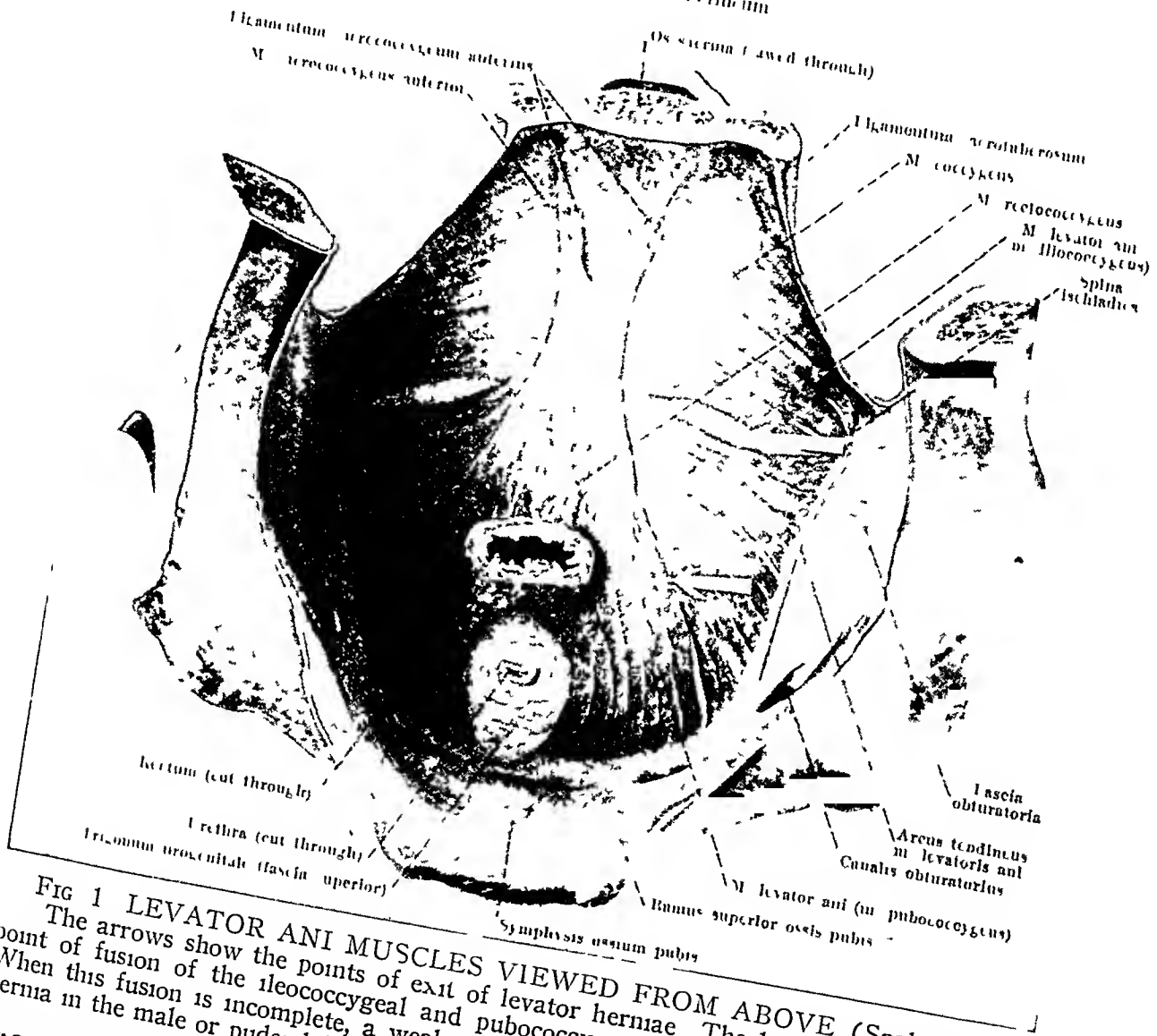


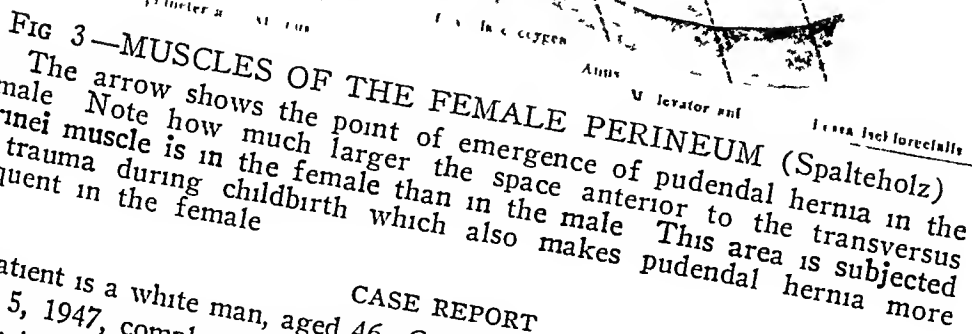
FIG 1 LEVATOR ANI MUSCLES VIEWED FROM ABOVE (Spalteholz)

The arrows show the points of exit of levator herniae. The lower arrow shows the point of fusion of the ileococcygeal and pubococcygeal portions of the levator muscle. When this fusion is incomplete, a weak area in the pelvic floor is present and perineal hernia in the male or pudendal hernia in the female may result.

strangulated perineal hernia in a man aged 73. Moschowitz's own case was a girl, aged 2½ years, who had a swelling of the buttock of six weeks duration. The mass presented between the ischium and anus and increased in size when the child cried. It was globular and firm. Through a para-rectal incision, a long fibroma attached to the peritoneum was removed. The peritoneum had been pulled down by the tumor through a defect in the posterior portion of the levator muscle. The wound was closed in layers and the patient was apparently well two years later.

PERINEAL HERNIA

type of obliteration of the cul-de-sac above and repair of the muscular and fascial layers below. Perineal herniae are usually repaired through the perineal approach by simple excision of the sac and repair of the disrupted muscle and fascia. No group of cases large enough to be statistically significant has come to my attention, but one gets the impression that approximately 50% are repaired successfully. The prognosis depends upon the strength of the muscle and fascia available for repair.



The patient is a white man, aged 46 Occupation, collector He was first seen by me September 5, 1947, complaining of a painful swelling to the left of the rectum
Past history—Appendectomy for acute appendicitis in 1946 In June and July of 1947 he had been given several injection treatments for hemorrhoids because of dis-

comfort in the region of the rectum. The discomfort was not relieved by the treatment. The patient has always been of a nervous temperament but has had no serious illnesses or accidents. His occupation of collecting installment accounts consists of calling from house to house and being in and out of an automobile and walking all day.

Present illness—The patient could not date the onset of his present disability accurately, but for about a year he had noticed a vague discomfort in the region of the rectum and for several months he had thought that there was a swelling to the left of the rectum. He stated that this swelling was not present all of the time, and that other doctors who had examined him had not found it. The discomfort gradually increased over a period of months and recently he has been carrying a soft cushion to church and other places where he expected to sit for any length of time. He developed a chronic low backache with some pain going down his legs. Recently he has been unable to do a full day's work and frequently has to go home and rest. There has been no fever and no abscess in this region.

Physical examination—The patient is a rather small, slightly built man who appeared to be rather highstrung and worried. His general physical examination was essentially negative except for the perineal region. When standing, there was a noticeable asymmetry of the buttocks with obvious fullness in the region of the left ischial tuberosity. This swelling disappeared almost completely when he lay down. There was no inflammation and no tenderness on palpation but manipulation of the swollen area caused moderate discomfort. There was a marked hernial impulse on coughing when standing or lying. No gurgling or gas was present. The hernial mass was soft and easily reducible. The mass apparently descended quite close to the lateral rectal wall, and a slight impulse on coughing could be felt through the rectal wall.

Roentgen-ray examination with barium given by mouth and by enema failed to show any intestinal loops in the left ischio-rectal space.

Cystoscopic examination showed no abnormality of the lower urinary tract.

Operation—September 18, 1947. Pentothal anesthesia. With the patient in Sims' position, a curved para-rectal incision over the left ischial tuberosity and buttock was made. The rectum was retracted medially. The ischio-rectal space was occupied by a fibrous mass about 3 x 8 centimeters in size. This mass was quite soft and cellular and, upon further dissection, was found to be firmly attached to the peritoneum. This mass could be easily displaced upward retroperitoneally into the hollow of the sacrum. When it descended into the ischio-rectal fossa, it pulled down with it a hernial pouch of peritoneum about 1.5 x 5 centimeters in size. This hernial mass emerged from the pelvis through a defect in the posterior portion of the levator muscle which was greatly attenuated and scarcely recognizable as such.

The fibromatous mass was enucleated without difficulty and was excised together with the hernial sac. The neck of the sac was closed at a high level with mattress sutures of atraumatic chromic catgut. The defects in the levator muscle and pelvic fascia were closed without tension with chromic catgut. These tissues were of poor quality. Use of a flap of gluteus muscle was considered but not used. The wound was closed with only one small Penrose drain which was removed in 24 hours.

The pathologist reported the fibrous mass to be a "fibrous hemangioma."

The postoperative course was uneventful. The wound healed per primum and now, two months later, there is no evidence of recurrence.

COMMENT

Aside from the rarity of a perineal hernia in a male, one other point seems to be of more than passing interest. In five out of eight cases of perineal herniae (six male cases collected from the literature, my own case and one case in a girl aged 2½ years) a tumor was present in the hernial mass. In one instance the tumor was malignant, in the other four it was benign. In

these cases in which tumors were present no loops of bowel were found in the hernial masses. Therefore, it seems likely that in approximately one-half of all true perineal herniae a retroperitoneal tumor is present and forms the wedge which penetrates the pelvic floor and incidentally drags the peritoneum down with it.

SUMMARY

A case of spontaneous perineal hernia in a man, complicated by a benign retroperitoneal fibrous hemangioma, with repair of the hernia, is reported.

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DR T. C. DAVISON, Atlanta, Ga. I have never seen such a case as Dr. Harrold has described, but in looking at the picture he has shown I can realize the possibilities. It reminds me of a story I heard many years ago. A young doctor having located in a small community was called to see a prominent citizen who had a strangulated hernia, and he advised immediate operation. There was a much older doctor in the community in whom everyone had a great deal of confidence, and the patient's family insisted upon having him in consultation. When the elderly doctor arrived and examined the patient, he said—"I have seen many such cases, it is nothing but a wind cyst and when you stick a knife into it you get nothing but wind and feces, and they all die."



NOTICE

The following statement is published at the request of Dr. Donald E. Barker whose article on "New Donor Areas in Skin Grafting" appeared in the March issue of the ANNALS OF SURGERY

"The Dermatome shown in the March issue of the ANNALS OF SURGERY, under the heading of "New Donor Areas in Skin Grafting, is an experimental model, manufactured with the permission of Mr. George Hood, owner of the patent on the Padgett-Hood Dermatome. Anyone desiring to purchase a Dermatome should contact the Kansas City Assemblage Company, Kansas City, Missouri, who are the sole manufacturers of the Padgett-Hood Dermatome."

THE MANAGEMENT OF PENETRATING ABDOMINAL INJURIES*

Comparative Military and Civilian Experiences

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HISTORICAL NOTE

THE EARLIEST REFERENCE in the literature to an abdominal wound is apparently in the *Anabasis*,¹ in which Xenophon described the plight of a Greek army captain who returned to his camp literally holding his bowels in his hands after an eviscerating wound of the abdomen. It was not until 1853, however, during the Crimean War, that any form of surgical intervention was recommended for such injuries. Then Baudens² suggested that in suspected internal injuries a small abdominal incision should be made, through which a sponge could be introduced, if the sponge returned bloody, the abdomen could be opened and the bleeding vessel ligated.

During the War between the States many surgeons on both sides spoke in favor of surgical intervention for abdominal injuries, but no one, so far as is known, acted on the advice. Available records, including one series of 3,690 cases,³ indicate that in that war the mortality of this type of injury was 90 per cent and more. In the years following the war civilian surgeons also advocated operation for abdominal injuries, but actually surgery did not then have a great deal to offer. The lack of a satisfactory anesthetic agent and the hazards of all surgery in the pre-Listerian era meant that the patient who was not operated on had about as good a chance of recovery as the patient submitted to surgery. The popular method of treatment therefore continued to be rest, starvation, and the administration of morphine.

After 1880 the voices favoring active intervention in abdominal injuries became louder. Surgical and anesthetic technics, while still crude by present-day standards, had so far advanced that laparotomy was not infrequently undertaken for abdominal and pelvic tumors, and there seemed no good reason why the same procedure should not be followed for the investigation and repair of visceral damage. The death of President Garfield September 19, 1881, from a pistol wound of the abdomen, did much to stimulate interest in active treatment for penetrating abdominal wounds, and the consensus of medical opinion was that he could have been saved by active surgical intervention.

In 1882 J. Marion Sims⁴ wrote "there is no more danger of a man's dying of a gunshot or other wound of the peritoneal cavity, properly treated, than there is of a woman dying of an ovariectomy, properly performed."

By 1887 Parkes⁵ was able to write "there are few modern surgeons, who, when confronted with a bullet wound of the abdominal walls, would explore the cavity. One is almost tempted to say that all cases are entitled to

* Read before the Southern Surgical Association at Hollywood Beach, Florida, Thursday, December 11, 1947.

the chance of life offered through operative procedure . . . However, if the abdominal wound is complicated or severe . . . or so great a time has elapsed as to allow . . . virulent inflammation, the probability is that the issue will be fatal ”

Thereafter surgical intervention was accepted as the better form of treatment. Many surgeons began to operate for abdominal injuries, and the results were frequently encouraging. Coley in 1891⁶ reported a mortality of 67 per cent in a series of 165 abdominal injuries and Fenner in 1901,⁷ in reporting a mortality of 59 per cent in 152 penetrating abdominal wounds, remarked, “ . . . despite the high mortality, I still think the indication for operation is pretty generally accepted the world over.”

These results, indeed, compared favorably with the mortality of 81 per cent in the 4,958 collected cases reported by Stimson in 1889,⁸ in all of which nonsurgical measures had been employed, and with the mortality of 90 per cent for abdominal injuries in the Spanish-American War. In the Boer War, at the turn of the century, the results were not much better, but there were certain reasons why surgeons could not then resort to operation. Distances were great. The heat was a serious problem. The supply of water was limited and usually contaminated. Transportation was slow and difficult. All of these factors were so serious in themselves, or so prolonged the time interval, that operation under the circumstances offered little more hope for recovery than did expectant treatment.

The point of view concerning abdominal injuries which prevailed during the South African War also prevailed early in World War I. It was not considered practical, under conditions of war, to set up field hospitals close enough to the line of battle to receive patients within the time interval required for successful abdominal surgery. This reasoning must be evaluated before it is condemned in light of the fact that many ambulances were still horse-drawn and that the motorization of vehicles of war was in its infancy. Moreover, the military authorities were severely objective in their planning. A battle casualty with an abdominal wound was regarded as having almost as little chance of survival as if he had been killed instantly, and the effort and equipment necessary to save the few who might survive were not considered justified.

Makins,⁹ who led the group of military surgeons committed to the policy of nonintervention in abdominal injuries, expressed the viewpoint of all military surgeons when he said “ . . . small gut lesions were practically always fatal, and . . . the success obtained by the ‘wait and see’ policy was due to the escape of the bowel, although the belly had been penetrated ”

The policy of expectant treatment for abdominal injuries did not, however, remain entirely unchallenged in World War I. An occasional civilian surgeon, newly in uniform, insisted upon prompt surgical intervention. The first operation for a penetrating wound of the abdomen in that war seems to have been done in December, 1914, by Captain John Campbell¹⁰ of Liverpool, who

successfully repaired two perforating bullet wounds of the stomach. Three months later Captain Owen Richard¹⁰ successfully resected 6 feet of ileum. Other surgeons advocated similar methods, and a gratifying, though small, reduction in mortality resulted. Wallace¹¹ reported 1,200 cases treated by surgery, with a mortality of 53.9 per cent, and Lockwood and Kennedy¹² reported 500 cases, with a mortality of 51.7 per cent.

In the decade following World War I the civilian statistics for penetrating abdominal injuries showed no significant improvement over earlier statistics. Mortalities of 48.2 per cent, 59.2 per cent, 61.4 per cent and 68 per cent were reported, respectively, by Billings and Walking,¹³ McGowan,¹⁴ Oberhelman, LeCount,¹⁵ and Prey and Foster.¹⁶ The mortality in the 1,299 cases reported by Loria¹⁷ from Charity Hospital of Louisiana at New Orleans for the period 1901-1930 was 62.3 per cent.

Between 1930 and 1942, however, three highly significant developments exerted a profound effect on the management of abdominal injuries. 1. A better appreciation of the fundamental pathology and pathogenesis of shock made possible an accurate estimation of the degree, as well as the prompt application of effective treatment before irreversible changes occurred. 2. A fuller knowledge of the protein and electrolytic constituents of the body made possible the correction of deficits in these constituents at the same time that more obvious blood loss was corrected. 3. Effective chemotherapeutics and antibiotics were introduced and their employment was put upon a rational basis, with the result that infection, as manifested by peritonitis, cellulitis and pneumonia, was no longer an uncontrollable problem in the management of abdominal injuries.

Even with these new developments, however, the mortality of abdominal injuries in civilian practice, except for small series of selected cases reported by single surgeons, remained extremely high. Rippy¹⁸ in 1941 reported 369 cases treated over a 17-year period, with a mortality of 60.5 per cent, a hopeful feature was that in the 29 cases treated in 1940 the mortality had been lowered to 41.3 per cent. In 1943 Hamilton and Duncan¹⁹ reported 190 cases of gunshot wounds treated over a 10½-year period with a mortality of 51 per cent, in the cases in which surgery was done the mortality was 48.9 per cent. In the same year Elkin and Ward³ reported 238 abdominal injuries with a mortality of 50.9 per cent. Two series of cases reported about this time from Harlem Hospital²⁰ showed a slight increase in mortality of the second series, from 59.3 to 62.6 per cent, but this experience, fortunately, was not indicative of the general trend.

PRINCIPLES OF MANAGEMENT OF WORLD WAR II

During the first years of World War II reports from British surgeons in the field showed no great improvement over World War I in the mortality of abdominal injuries which remained in the neighborhood of 60 to 70²¹ per cent. On the other hand, these statistics were far more accurate than the statistics of World War I which usually did not take into account deaths

from shock and hemorrhage on the battlefield and which were actually somewhat higher than they seemed. In World War II the excellent system of evacuation resulted in the admission to field hospitals, and therefore to the benefits of surgery, of many men who in World War I would have died on the battlefield. There were also extenuating circumstances. As in the Boer War, transportation of the wounded over the desert areas of North Africa was difficult and hazardous, and the long supply lines, over which even water had to be brought, introduced difficulties that frequently were insuperable. To the credit of the surgeons who carried on under such tremendous handicaps it must be said that their results showed a progressive improvement and, as the war progressed, the surgical mortality for abdominal injuries in the North African Theater compared favorably with that of any other group.

By the time American Armies entered combat late in 1942, the management of abdominal injuries was fairly well standardized. It called for medical aid at the earliest possible moment, though first aid, it is true, was frequently limited merely to the administration of morphine, the application of sulfa crystals to the wound (a practice later discarded), and the application of sterile gauze pads. Whenever possible, plasma or whole blood was given before the patient reached the first medical installation.

The policy of surgery for abdominal injuries had become generally accepted by the time American Armies entered combat, and certain lessons concerning their management had also been learned. One was that while prompt operation was desirable, movement to installations in the rear, where surgery could be done, was necessarily slow under military conditions. The solution of this problem was the establishment of field hospitals far forward in the combat zone. These hospitals were equipped with surgical supplies and were staffed with competent surgical personnel, so that shock could be treated adequately and extensive surgical procedures of urgent character could be performed on any part of the body.

A second lesson which was learned early in the war was that casualties with abdominal injuries did not tolerate early transportation after operation. Field hospitals were therefore equipped and staffed to hold such patients for at least 10 days after surgery, and longer if necessary, and an important factor in the earlier mortality of abdominal injuries was thus practically eliminated.

A third lesson of the early days of the war was a realization of the importance of triage at the level of the clearing station. The choice of the right time for surgery on the right patient must be credited with a large portion of the salvage of casualties which distinguished World War II.

In contrast to earlier practice, no wounded soldier in World War II was ever denied the possible benefits of surgery because his condition was regarded as poor, or even as hopeless. If he could be brought to the operating room alive he was given whatever chance he might have. In general, this policy increased the surgical mortality, because in many instances such patients died on the operating table or within a few hours after operation. On the other

hand, the almost miraculous recoveries which sometimes occurred were full justification for it

RESUSCITATION

The time interval between wounding and operation was kept at an astonishingly low level, the average being 10 to 12 hours, but the brief lapse was not regarded as the most important consideration in the management of abdominal injuries. Patients with active, massive hemorrhage were operated on as promptly as possible, but in the absence of such bleeding, time was deliberately taken to administer blood, plasma and electrolytes according to the indications of the special case. During this interval dirty battlefield clothing was removed, body heat was restored, sedatives were administered, and such diagnostic procedures were carried out as would determine accurately the location and extent of the abdominal injuries. The special shock teams responsible for resuscitation played a major role in the reduction of the mortality of abdominal injuries in World War II.

TECHNICAL CONSIDERATIONS

All the important technical points in the management of abdominal injuries have been described numerous times and need not be repeated in any detail. Operations were performed expeditiously according to a definite plan, which reduced the percentage of error and the working time to a minimum. Shock therapy was continued throughout the procedure and until all danger of hemorrhage and peritonitis had passed.

The management of wounds of the colon and rectum, however, provided one of the outstanding contributions of military surgery in World War II. The basic principles of therapy were (1) routine exteriorization of the traumatized bowel whenever it could be sufficiently mobilized to bring it outside of the abdomen, and (2), the subsequent use of the segment as a colostomy. When mobilization was not possible, proximal loop colostomy was employed. No attempt was ever made to repair simple perforations of the colon, and resection was regarded as preferable if the damage was extensive. Resection was the method of choice for the treatment of injuries of the right side of the colon, especially if the terminal ileum was also damaged.

Injuries of the extraperitoneal portion of the colon and of the rectum were never left untreated, no matter how inconsequential they might seem. Infected fistulas which followed improper treatment were particularly serious if the pelvic bones had been damaged, osteomyelitis was then an almost inevitable consequence. The lesson was finally learned that complete diversion of the fecal stream was essential in all injuries of these portions of the large bowel, and it was also found that this could be accomplished only by some method which separated the colonic stoma or which closed the opening in the distal loop, or by providing a second colostomy in the proximal (transverse) loop of colon.

Colostomy had been suggested as a method of treating injuries of the colon in World War I but seems not to have been used except in the most serious

cases The result was that the method was in ill repute even before it had had a fair trial In the interval between the wars, civilian surgeons frequently brought certain tumors of the bowel outside of the abdominal cavity and created a spur colostomy, which required crushing at a later date to reestablish continuity of the bowel The same procedure was obviously adapted to military usage, and the military surgeons of World War II were in a receptive mood for it, in view of the extremely high mortality which other methods of treatment had previously accomplished It is to the Surgical Consultant of the British Army, Sir H G Ogilvie,²² that the chief credit is due for insisting upon routine exteriorization of the wounded colon with colostomy, as well as the use of colostomy for all injuries of the rectum and extraperitoneal colon These methods were found highly effective in the treatment of casualties of the first air raids over England, and they were carried over into the North African and Mediterranean Theaters by the British military surgeons. American surgeons used the same methods without, however, knowledge of the British practice, from the time of the first landings in North Africa in November, 1942, and they were soon thereafter made the official practice

Colostomies were usually closed in the general hospitals of the Zone of Interior The operation was at first undertaken with a good deal of timidity, for military surgery is not civilian surgery and there was justifiable doubt as to how the stoma had been created, a doubt which the information on field medical cards did relatively little to dispel At first spurs were crushed outside of the peritoneum, as in civilian practice, but the results were not good Many times the spur was short and inadequate and sometimes it was non-existent The application of a clamp or enterotome was therefore dangerous as well as painful Moreover, rotation of the loops, sometimes for as much as 180°, was often noted, and mesentery and loops of intact bowel were often found interposed between the colostomy loops Hemorrhage and necrosis of the bowel wall also occurred

Extraperitoneal closure of a colostomy created under battle conditions was obviously not parallel to closure of a colostomy created under civilian conditions, but originally there was doubt as to the safety of the intraperitoneal technic As experience accumulated, however, it became evident that this technic was considerably less dangerous than the more or less blind extraperitoneal technic Apparently the peritoneal cavity could be entered with impunity, probably because the peritoneal tissues had been vaccinated against infection by the reaction which occurred following injury During the latter part of the war, therefore, it became routine to open the peritoneum widely, release adhesions, repair the bowel by an end-to-end or lateral anastomosis, and replace the colon into its normal position The results were uniformly good Complications were few, and the mortality in some series of cases was less than 0.5 per cent

MORTALITY

The principal causes of death in abdominal injuries were shock, hemorrhage, peritonitis and pulmonary complications, in that order of frequency As

Ogilvie²² well expressed it, deaths which occurred in the first two hours after wounding were due to hemorrhage, in the first two days to shock, and in the first two weeks to infection. The majority of deaths occurred within 48 hours of wounding, and it was soon evident that patients who could not be brought into field hospitals within that period had very little chance of recovery. On the other hand, while the time factor was important, the so-called multiplicity factor was found to be even more important. A patient's chance of survival depended upon the number of organs injured, the mortality rising progressively as the number of injured viscera increased.

Less frequent causes of death included ileus, thrombo-embolism, intestinal obstruction, chronic sepsis, lung abscess, liver abscess, subphrenic abscess, gas bacillus infection, hemopneumothorax and meningitis. All these complications were managed by the methods usually employed in civilian practice.

The Second Auxiliary Surgical Group, which saw active service in Italy, France and Germany, treated more than 3,500 abdominal wounds with a gross mortality for the surgical cases of 25.5 per cent.²³ From the 38th Evacuation Hospital, which also saw active service, Imes²⁴ recorded a mortality of 20 per cent for 358 abdominal injuries treated surgically. Bradford and Campbell²⁵ reported a mortality of 16.7 per cent for 443 operations, while Rohlf and Snyder²⁶ recorded the extraordinarily low mortality of 11.9 per cent in 67 cases.

THE APPLICATION OF MILITARY EXPERIENCES TO CIVILIAN SURGERY

The military experiences of World War II proved clearly that the mortality of penetrating wounds of the abdomen can be lowered drastically by proper surgical procedures. There seems no reason why similarly good results should not be achieved in civilian surgery for the same conditions. It is true that in the Army, surgeons were dealing with young, healthy adults, in the prime of physical condition, though that advantage was frequently offset by the fact that the men were tired, often to the point of exhaustion, that they were dirty, that in some instances they had not bathed for weeks, that they were likely to be dehydrated, and that frequently they were none too well nourished because they had lived on limited rations, sometimes for long periods of time. Moreover, many other circumstances were unfavorable, including difficulties of transportation, often under enemy fire, hospitals that, however well equipped, were necessarily makeshift, and personnel that was frequently in short supply.

An analysis of abdominal injuries in civilian practice reveals, on the other hand, numerous favorable factors. Most patients who suffer this type of injury are young adults, who are seldom more than 40 years of age. They are likely to be physically active. They live in city districts, where ambulance service is prompt, hospitals are near at hand, and medical supplies and personnel are plentiful.

That a gratifying decrease in the mortality of abdominal injuries can be achieved in civilian practice has already been demonstrated. In 1944 Sloan²⁷ reported from the Johns Hopkins Hospital a mortality of 14.3 per cent in a

series of 59 cases treated after 1939, when the plan of treatment was changed and when, in particular, transfusion was used frequently and chemotherapy was employed routinely. In 1947, at Grady hospital in Atlanta 62 cases of perforating rifle- and pistol-shot wounds were treated surgically with only 11 deaths, 17.7 per cent.²⁸ There seems to be no good reason why similar or better results should not become the rule.

CONCLUSION

The results achieved in abdominal injuries in World War II have never been surpassed in the history of surgery and have been equalled only in small series of selected cases treated by highly skilled surgeons. There is ample credit for all who participated in this achievement, but the young men who performed the bulk of the operations deserve the bulk of the credit. The skilful surgical technic and the brilliant surgical judgment exercised by them at the operating table established for all time the value of the residency system which had come to full flower between the wars. It was here that these young men demonstrated how well they had learned the lessons which they had been taught.

Gordon-Taylor,²¹ whose experience in World Wars I and II probably surpasses the military experience of any living surgeon, paid them a tribute with which I might well conclude this paper.

Ideals may be for pursuit and not for attainment, but he would be bold indeed who ventured to foretell that in this province of surgery the zenith of our achievement has yet been attained, already, indeed, the recovery-rate in the hands of a few individual surgeons, whom Luck has perhaps brushed with her wings, or who may have been blessed in the matter of environment or fortunate in other ways, has been of almost astronomical magnitude. There is much, therefore, to substantiate the claim of the young surgeon that in the treatment of abdominal casualties of war he has surpassed his teachers and the previous generation of war surgeons.

Macte virtute, puer, esto. Sic itur ad astra

Well done, young man. That is the way to glory

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DISCUSSION—DR PAT R IMES, Louisville, Ky As Dr Poer indicated, the greatest mortality factor in abdominal injuries in World War II was shock Because of its importance and frequency in such injuries, the greatest benefit resulted from readily available whole blood which the Services provided for their care I believe such availability of blood in civilian practice will show comparable improvement in the results A review of the records of 53 patients admitted to the Louisville General Hospital because of abdominal trauma during 1946 showed that there were 15 deaths, two before surgery, five on the operating table and five within 24 hours following the operative procedure I feel that these 12 of the 15 deaths might be attributed directly to the presence of shock I also found that, in spite of our war experience, we were utilizing an average of 625 cc of blood preoperatively and during the operative procedures, an obviously inadequate amount

Regarding the policy of exteriorization of colonic wounds, there was not uniform agreement on this subject during the war I did not feel that it should be practiced routinely and some of the British toward the end of the war likewise indicated their preference for primary closure in selected cases On reviewing our experience in the Mediterranean theater, we were able to collect 168 cases who had primary suture of the colonic injury with a mortality rate of 24 per cent, which not only compared very

favorably with that following exteriorization (35 per cent in 945 collected cases), but effected a greatly improved morbidity record

DR AMOS R KOONTZ, Baltimore I would like to cite one instance of what an enterprising doctor can do under adverse circumstances, and without the benefit of modern knowledge Dr Poer's mention of the Greek soldier coming in carrying his intestines in his apron, in the time of Agamemnon, reminded me of this Some years ago I had occasion to write a paper on traumatic rupture of the diaphragm, and in looking up the literature I came across Holmes' System of Surgery in the Medical and Chirurgical Faculty Library in Baltimore This work comprised three volumes, and was published about 1870 The chapter on gunshot wounds was written by Dr Hunter McGuire, who had been chief surgeon of the Second Corps of the Army of Northern Virginia, commanded by Stonewall Jackson Dr McGuire probably at that time knew more about gunshot wounds than any other man living He had seen thousands of them in both Federal and Southern soldiers Dr McGuire made a reference to a case handled by two Doctors Amiss, which excited my curiosity, as I came from the same county in Virginia from which these doctors hailed The doctors were Drs Thomas B and William H Amiss Mr Fred Amiss, the son of Dr T B Amiss, was still living in Luray, Virginia, so I wrote to him and asked if he knew anything about the case mentioned by Dr McGuire He wrote me substantially the following account of the incident

Just after the battle of Cedar Mountain in 1862, Jackson's corps was on the march along a country road covered with about six inches of dust The two Doctors Amiss, riding along this road, came across an officer lying beside the road Superficial examination disclosed the fact that he had been disemboweled by a shell fragment, and his intestines were lying out on the ground, without any perforation, however Cavalry, infantry and artillery had been marching along this road, so that the intestines were covered with a very thick coating of dust One of the two doctors said to the other—"I reckon the only thing we can do with this fellow is to dig a hole and roll him into it" The wounded officer, much to their surprise, was conscious, and replied as follows—"If you damned doctors would do something for me I would get well I had a hound dog who ran a mile once with his guts out I sewed him up and he got well I am as good as a hound dog, am I not?" The doctor then said—"This fellow is full of sand and grit in more ways than one, so we will see what we can do for him" They then had him moved to a nearby farm house, where they made up some salt solution, washed off his intestines, put them back into the abdominal cavity, and sewed up the wound In three months the officer was back on active duty again The officer was Colonel Snowden Andrews, of Baltimore, and the incident is briefly referred to in a footnote in one of the three volumes of Lee's Lieutenants, by Dr Douglas Freeman

MR GUY BLACKBURN, Guy's Hospital, London, England I am very much interested in the subject of this paper, and would like to congratulate Dr Imes on his contribution It takes me back to a Surgical Conference held in Rome in 1944, attended by British and American surgeons in the Mediterranean theatre, and presided over by Colonel Churchill Wounds of the colon formed one topic of discussion, and one surgeon after another gradually confessed to intraperitoneal suture without exteriorization At this time this was regarded by those in authority as unwise, but experience showed that it was safe in properly selected cases For my own part I found exteriorization of the right side of the colon very unsatisfactory indeed, and went to any length to avoid it

Like the other speakers, I have seen eventration of abdominal viscera, but I believe it to be prognostically of good significance If viscera are immediately protruded and cannot be reduced spontaneously, it implies that the wound of entry is a small one It is commonplace too that the intestinal damage in these cases is nearly always in the extruded gut without any intraperitoneal injury Resection is usually necessary but results justified it

Lastly, I should like to say one word about figures, and the folly of trying to com-

pare them in the two World Wars. Circumstances were so different, the types of wounds were quite different, the missiles were not the same. The principle was also recognized of bringing the surgeon to the wounded man, and not the wounded man to the surgeon. Operations, therefore, were done on the whole much earlier but not, I am sure, with any more technical skill. Nobody publishes rejection rates, and mortality rates without them mean nothing. Another factor, almost impossible to assess, is the interdependence of associated wounds, which account for as much as 15 per cent difference in complicated and uncomplicated abdominal injury.

I would end, Sir, by thanking you for your kindness in having me here, and Dr Blalock in particular for asking me to such a delightful meeting of the Southern Surgical Association.

DR DAVID HENRY POER, Atlanta, Ga (closing). I appreciate very much the remarks of all the discussors. I am sure there are no real points of argument because the desire of all of us is the same, viz, to continue our efforts to lower the morbidity and mortality of this common type of injury, both in civilian and military experience.

Our civilian experiences were carried into the army, and now we want to reverse the procedure and bring back the things we learned in the army to our civilian work. In dealing with such a large number of cases many methods of treatment were carried out and we are now in a position to choose the ones that produced the best results.

I am familiar with Dr Imes' experience in the 38th Evacuation Hospital where some primary sutures of colon injuries were done, and as mentioned by Mr Blackburn, other surgeons in the British Army did the same with good results, but I think on the whole that in dealing with such a large number of surgeons of varying ages, experience and judgment, it was better to follow the policy of exteriorization, and the over-all mortality figures prove that right. Mr Blackburn's comments regarding the advisability of doing a primary resection for injuries to the right colon are in agreement with our experiences.

In conclusion, I believe that the high mortality for perforating wounds of the abdomen which exists in most of our large city hospitals today is due to the following factors:

(1) inadequate treatment of shock, not enough blood is given and treatment is not continued long enough after operation, (2) patients with active and profuse hemorrhage are treated for shock for too long before operation—operation must be started promptly in such patients, (3) chemotherapy is frequently inadequate, and (4) too much major surgery is put in the hands of a young and inexperienced house staff, with resulting prolongation of the operation and mistakes in judgment. The cure for these is obvious and within the reach of all of us.

NOTICE

The ANNALS OF SURGERY takes pleasure in printing the program of the Second Annual Meeting of the SOCIETY FOR VASCULAR SURGERY. The objects of this society are to promote the study and research in vascular diseases, to define more clearly the role of surgery in these diseases, to pool the experience and knowledge of its membership, to standardize nomenclature, to promote and encourage adequate teaching of these diseases to students, interns and residents, to encourage hospitals to develop special sections in vascular surgery and to provide special training for young surgeons interested in this field. Because of the recent rapid advances in this field, it is thought that many members of the surgical profession may be interested in attending the Meeting of this Society.

THE SOCIETY FOR VASCULAR SURGERY

Second Annual Meeting
Stevens' Hotel, Chicago, Illinois
Sunday, June 20, 1948

MORNING SESSION

1. Allen, Arthur, W.—President's Address
Present Evaluation of the Prophylaxis and Treatment of Venous Thrombosis and Pulmonary Embolism
2. Homans, John,
The Management of Recovery from Venous Thrombosis in the Lower Limbs
3. De Bakey, Michael E. and Ochsner, Alton,
Gangrene as a Complication of Thrombophlebitis Case Report and Review of the Literature
4. Beck, Claude S.
Revascularization of the Heart
5. de Takats, Geza,
The Cortico-Adrenal Factor in Essential Hypertension
6. Pearse, Herman, E.
Cellulose and Cellophane Products in Vascular Surgery

AFTERNOON SESSION

1. Elkin, Daniel E. and (by invitation) Cooper, Frederick, W. Jr.
Radioactive Isotopes in the Investigation of Vascular Disease
2. Veal, J. Ross.
The Surgical Treatment of Hyperhidrosis
3. Coller, Frederick and (by invitation) Campbell, Kenneth N., Harris, Bradley and Berry, Robert, E. L.
An Evaluation of Lumbar Sympathectomy in Far Advanced Arteriosclerosis Obliterans
4. Smithwick, Reginald H. and (by invitation) Whitelaw, George P.
The Effect of Sympathectomy upon Heart Rate and Possible Therapeutic Applications

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- 5 Herman, Louis G and (by invitation) Buchman, Joseph A
Complications Resulting from Injuries to Arteries
- 6 Blakemore, Arthur H
Portacaval Anastomosis for Portal Hypertension—Follow-up Results
- 7 Gage, Mims
Cardiac Decompensation Secondary to Arteriovenous Fistula with Report of
Two cases
- 8 Freeman, Norman E
A Technique for Division and Suture of the Patent Ductus Arteriosus in
the Older Age Group
- 9 Linton, Robert R
The Arteriosclerotic Popliteal Aneurysm Treatment by Sympathectomy
and Aneurysmectomy



THE DEFINITION OF INOPERABILITY OF CANCER*

GEORGE T PACK, M D

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NEW YORK, N Y

THE GREATEST MARGIN FOR ERROR in reporting the end-results of treatment for cancer may be found in the classification by the reporter of a regional or histologic type of cancer as operable or inoperable. The difficulty in correcting this fault is apparent when one realizes that three variable factors interplay in the pronouncement of a given cancer as non-resectable by any surgeon, namely first, the condition of the patient as regards his age, the co-existence of degenerative diseases and the complications attendant on the presence of the cancer, second, the extent of the disease, meaning the degree of local or organic involvement, the specific organ or tissue implicated, the extension to and incorporation of neighboring viscera by the cancer and metastases to regional and distant sites, and third, the surgical philosophy, moral point of view, courage, and experience of the surgeon. In a large group of patients with generalized bone metastases, or diffuse involvement of lungs or liver, or peritoneal carcinosis or melanomatosis, the recognition and acceptance of inoperability is obvious to any physician. But there are too numerous other instances in which the definition of inoperability may be subjected to careful evaluation, criticism, and even condemnation.

THE POINT OF VIEW OF THE SURGEON

It is not the purpose of the writer to formulate a set of rules governing the behavior of the surgeon in a given circumstance, but rather to present certain arguments for extending the scope of operability for cancer. The very nature of this disease, the infirm and often aged patients in whom it so frequently develops, and the radical character of the numerous operations designed to combat it, all conspire to make the surgical treatment of cancer a hazardous venture for the patient and often an ordeal for the surgeon. With the knowledge of the inevitability of death from cancer that is not treated, it seems unnecessary to state that no surgeon would refuse a patient the slightest chance for cure or

* Read at the Section on Surgery of the New York Academy of Medicine, January 2, 1944

even relief because of a fear of criticism for failure or an unnatural pride in low figures for operative mortality. Nor should any surgeon attempt to play God and decide arbitrarily that a certain cancer patient had lived a sufficiently long life or that he had so few remaining years of even normal life expectancy that operation at best would hardly be worth while. We must take care in our weighty decisions concerning the denial or offering of a chance for life to a patient, that in our desire not to be the executioner, we achieve the same end-result by acting as an immoral judge. For example, if called upon to operate for a ruptured duodenal ulcer on a condemned criminal awaiting electrocution in the death row, the surgeon by his calling and in keeping with the Hippocratic Oath, operates with the same skill and renders just as meticulous postoperative care as if his patient were to live forever.

INOPERABILITY AND INCURABILITY

Many operations designed for the cure of cancer achieve in too many instances only a palliative end-result. If inoperability were an absolute state, and not a variable one, dependent in some cases on the criteria of the surgeon, the term would be synonymous with incurability. The unpredictable behavior of cancers and the immeasurable host resistance of organs and tissues to the growth of cancer combine in creating many intangible factors that make the early cancer occasionally incurable and the advanced cancer sometimes controllable. Assuming that a given cancer is not suitable for radiation therapy, operative removal becomes the only recourse. At the time of laparotomy, for example, a surgeon may be compelled to render judgment absolutely governing the life of the individual, the decision necessitating a matter of a few minutes as compared to days and weeks of courtroom deliberation by judge and jury. The closure of an abdominal wound on a cancer that is obviously hopeless is always done reluctantly, but the abandonment of an operation that is of questionable accomplishment must plague the conscientious surgeon for many sleepless hours and is one of the many reasons why he remains forever humble. He must worry whether his definition of inoperability is in his state of mind or moral courage or in the actual stage of the cancer. An aggressive attack on cancers presenting almost insuperable technical difficulties will sometimes result in palliative relief and occasionally in cures, but with mounting operative fatalities. Under these conditions, no one would impugn the good intent of the operator.

THE AGE OF THE CANCER PATIENT

One cannot become reconciled to the perverted point of view of some surgeons who are reluctant to operate on aged patients for major forms of cancer. Minor cancers that run a chronic course may not endanger the life of the patient, but a major cancer should be removed regardless of the age of the patient, providing it is technically possible and his physical state is not too precarious. The anatomic and physiologic age of the subject are infinitely more important than the chronologic age. At times, it would seem wiser to leave the actual age off the chart or for the patient conveniently to forget the

number of years he has lived if the knowledge of age alone unfavorably influences the surgeon, the fitness for the surgical ordeal would then be rightly determined by the true condition of the patient as judged by physical examination and laboratory tests. As examples, we have successfully performed hemi-colectomy for cancer of the cecum in two patients more than 80 years of age, in one of whom the operation was done under local anesthesia because of intussusception of long duration. A 92-year-old physician was cured of cancer about which he was genuinely concerned. The proverbial three score years and ten, however collectively applied, do not concern us when we reach that age, because most of us, including patients, live from day to day and year to year as if we were immortal. Some aged patients continue to possess a zest for life, and they merit every opportunity for cure or relief from otherwise fatal diseases that accidentally befall them, this is their privilege and their right regardless of advanced years just as their rights of franchise, speech and worship continue. Rather than refuse to operate, the surgeon may justifiably modify or simplify the character of the operation, for example, do a simple mastectomy under local anesthesia for cancers of the breast that have apparently not metastasized to the axilla.

THE CONDITION OF THE PATIENT

For every argument advanced against the decision to operate on any given patient, the irrefutable defense or rebuttal is the inevitable fatality from the untreated cancer. What would the surgeon do if confronted with an acute surgical emergency in the same patient, e g, a ruptured duodenal ulcer or gangrenous extremity? A patient with cancer, who is gravely ill from the conjoined effects of the cancer and intercurrent diseases, of course would receive medical consultation, careful deliberation concerning the choice of anesthesia and meticulous preoperative preparation. The family should jointly assume with the surgeon the responsibility of undertaking to remove a major cancer in a patient who is a serious operative risk.

One illustrative case is that of an elderly woman, bedridden and almost helpless for years due to amyotrophic sclerosis, on whom a radical mastectomy was done. This chronic invalid was a most cheerful individual and the nucleus of a happy home with husband and children even more affectionate and concerned about her recovery and cure than is ordinarily the case. A 70 year old woman, seriously handicapped by heart disease, underwent an almost total gastrectomy for a huge leiomyosarcoma of the stomach. The jejunum was anastomosed to only a rim of stomach below the cardia. After a stormy convalescence, she recovered and now, 12 years later and 82 years old, is living and well except for the necessity of supportive treatment for her heart. An elderly woman entered the Memorial Hospital with a leiomyosarcoma of the uterus so large that it filled the entire abdomen and extended up as far as the epigastrium. She was in severe heart failure, did not respond to medical treatment, and was classified as inoperable by cardiologists who warned us not to attempt any surgical procedure. On the other hand, she

was experiencing hemorrhages of increasing severity. Because she could not lie recumbent, the operation was done in a modified Fowler's position, and under local anesthesia, an incision was made from the pubis almost to the ensiform cartilage. A pan-hysterectomy was done under local anesthesia including a liberal vaginal cuff. She was discharged from the hospital two weeks later with greatly improved cardiac compensation due, we thought, to the removal of this massive tumor.

THE STAGE AND EXTENT OF THE CANCER

The inoperability of an abdominal cancer is unquestioned in the presence of extensive hepatic metastases or peritoneal carcinosis. If a patient, on laparotomy, is found to have a few metastases in the liver without hepatic dysfunction or hard, irremovable retroperitoneal lymph nodes, one may still proceed with the removal of a cancer of the stomach, colon, or rectum, because experience has shown that gastric, colonic, or rectal resection is the best palliative measure for such cancers, though admittedly incurable. Here again, clinical judgment must influence one's decision, as nothing is gained by enabling a patient to live longer and suffer more. The measure of palliation accomplished by such resection is not necessarily the longer duration of life but the degree of freedom from distress. A lobectomy for a solitary metastasis in the lung in a patient who had experienced an amputation of an extremity for osteogenic sarcoma would have been considered meddling surgery a decade ago, but not in the light of the present day viewpoint. Three brief case reports will serve to illustrate an unpredictable salvage of life by surgical persistence in the face of overwhelming odds.

Case 1 D. D., a 24-year-old man, had a congenitally defective left hand, characterized by crossed fingers with contractures. For several years, a tumor had been slowly growing deep in the palmar space. An attempt at removal in another hospital was only partly successful, the specimen was reported by the pathologist as a neurosarcoma. An amputation through the forearm was done, followed in 17 months by recurrence in the stump, the arm was then amputated through the mid-humerus well above any clinical and microscopical evidence of the tumor. Within a year, another recurrence was observed and was treated by a disarticulation of the humerus. There was no evidence in the specimen of upward extension of the neurosarcoma. Subsequently, a mass was palpated in the axilla, aspiration biopsy was positive for sarcoma. The patient consented to an interscapulothoracic amputation which was performed on February 25, 1935. Surely, we reasoned, this will control or eradicate any possibility of recurrence of the sarcoma, but a few months later, another mass, somewhat fixed, was palpated in the lower neck. With determination but not with optimism, we performed a difficult dissection of this sarcoma from the brachial nerve plexus which it involved, the operation was terminated by inserting gold radon seeds in the wound. This last desperate surgical attempt (the sixth) was done 12 years ago. Since that time, the patient has gone to college, married, fathered two children, and become a successful teacher in a normal school. There has been no evidence of metastasis and no evidence of local recurrence of the neurosarcoma.

Case 2 N. H., a 30-year-old male, was referred to the Memorial Hospital in 1932 with a clinical diagnosis of melanoma of the skin of the chest. A bluish-black ulcerating tumor 2 cm in diameter was seen in the pectoral region, there were large firm nodes in the corresponding axilla. The primary melanoma was surgically removed.

and the axilla was dissected, the lymph nodes contained metastatic melanoma. Several months later, a rapidly-growing black, fungating tumor was observed on his bald scalp. It was removed and microscopically proved to be a malignant melanoma. In the course of the next year, numerous other bluish-black, rapidly-growing nodules 0.5 to 2 cm in diameter appeared on his trunk, back, and arms. The clinical picture was typically that of disseminated melanoma in the skin, so much so that our professional colleagues in consultation commented on the futility of further surgical efforts. Nevertheless, we persisted in removing these tumors as they appeared, our only encouragement derived from the opinion of our pathologists, Dr. James Ewing and Dr. Fred Stewart, that these malignant melanomas had the peculiar features of new, independent, or primary growths rather than metastatic foci. The condition was further complicated at this time by the appearance of metastases in the opposite axillary lymph nodes, which were treated by radical axillary dissection. A total of 14 primary malignant melanomas were removed and both axillas were dissected for proved metastatic melanoma. It has been over ten years since the last operation, and the patient is well, without evidence of recurrence in this long interval. The satisfactory end-result is not due to any major surgical feat, but rather to the determined philosophy of treating cancer wherever it may be found.

Case 3 D. B., an 11-year-old southern schoolgirl, had a small nodule in the thyroid gland of which her parents had long been aware. Within two months after the somewhat precocious onset of menstruation, this nodule grew with alarming rapidity. A local surgeon was consulted and one of many palpable lymph nodes in the neck was removed for biopsy. It contained metastatic thyroid cancer. When we examined her, the thyroid cancer was infiltrative, fixed, and inoperable. Innumerable firm lymph nodes, involved by the disease, were felt throughout both cervical chains. Inasmuch as the cancer was inoperable, intensive treatment was given with the four gram radium element pack, supplemented by the interstitial deposition of gold radon seeds in measured tissue doses in the thyroid gland and remaining palpable lymph nodes. The dose was epidermal but effective in causing satisfactory regression of the cancer. Just before she was scheduled to return to her home in Alabama, she complained of headache, vomiting, and blurring of vision. Ophthalmoscopy revealed bilateral choked discs. A presumptive diagnosis of metastatic thyroid cancer to the brain was made. A ventriculogram showed the presence of a tumor encroaching on the lateral ventricle. At this time, the parents obtained conflicting advice, some physicians defining her condition as hopeless. Motivated by the same policy of continuing the treatment of cancer wherever found and influenced by the remote and even unlikely possibility of the intracranial tumor being unrelated, I urged craniotomy and surgical removal. This point of view was identical with that of the neurosurgeon, Dr. Byron Stookey, who performed the operation and removed the tumor which was situated in the choroid plexus of the lateral ventricle. To our dismay, but without surprise, the histologic study revealed metastatic thyroid cancer. This little girl matured gracefully, completed her academic and collegiate education, married, and became the mother of two children. She is now living and well 15 years after her treatment was completed.

INVOLVEMENT OF MULTIPLE ORGANS

One of the outstanding achievements in the surgical treatment of gastrointestinal cancer is the unexpected good result which frequently follows the removal of cancers that have become adherent to adjacent organs and are at first examination seemingly inoperable. The explanation lies in the fact that cancers of the stomach, colon, and rectum, which are papillary or polypoid in character, often become grossly infected and, as a consequence, the organ becomes adherent to adjacent viscera or structures. These tumors appear

technically irremovable and give the false impression of extension of the cancer beyond the confines of the organ primarily involved. By perseverance and meticulous dissection, associated at times with the sacrifice of a portion or the whole of the adjacent organ, the surgeon can often remove this growth successfully. The subsequent pathologic report, in many instances, will reveal that the cancer itself had not extended to involve the neighboring organ, and that the adhesions were of inflammatory character, in fact, the cancer itself may be classified as of relatively low-grade malignancy. I have known of numerous instances in which complications of this character were found, and yet no regional metastases to nodes were discovered on careful microscopical survey. These facts encourage one to attempt by every means possible the removal of cancers which are adherent to any structures that may be sacrificed by excision and continuity with the organ involved.

A STOMACH

Although total gastrectomy had been attempted within a few years after Billroth's initial partial gastrectomy for cancer, the operation did not find popular acceptance by gastric surgeons until the past decade. It is now known that the entire stomach can be safely removed and the individual live thereafter without too great inconvenience and without too disturbing metabolic changes. On the Gastric Service of the Memorial Hospital, we have performed approximately 50 total gastrectomies for cancer and approximately 50 transthoracic resections of the lower esophagus and upper end of the stomach for cancers of the proximal gastric segment. In past years, the very location of the cancer, juxtaposed to the cardia, was sufficient to pronounce it inoperable in many hospitals, in consequence of which 8 to 10 per cent of all patients with gastric cancer were denied surgical intervention merely because of the accidental location of the cancer near the region of the cardiac orifice. The extension of the cancer to involve the esophagus, both below and above the diaphragm, called for a popularization of the operation of transthoracic, transdiaphragmatic esophago-gastrectomy. This procedure has now been well established. The end-results of this operation and the preoperative and postoperative management are so improved that these cancers can no longer be classified as inoperable because of location only. In these 100 cases of extremely radical surgery removal of gastric cancers, we have found many occasions to remove adjacent organs in whole or in part. Segments of the diaphragm, the entire spleen, variable portions of the pancreas, part of the left lobe of the liver adherent to or invaded by the cancer, and large segments of the transverse colon have all been removed in continuity with the entire stomach on numerous occasions. In the earlier years of gastric surgery, any one of these complications, i. e., the adherence of such organs to the stomach, would have constituted an excuse for classifying the cancer in that particular patient as irremovable.

B DUODENUM AND PANCREAS

Successful operations for malignant tumors of the duodenum, in years

past, were limited to the rare occasions when a transduodenal resection of an early polypoid tumor of the ampulla of Vater could be done. All other cancers of the duodenum and pancreas were considered inoperable because surgical ingenuity had not devised a method of removing the duodenum and pancreas with re-establishment of biliary flow and gastro-intestinal continuity until Allen O. Whipple and his co-workers conceived of the principles now well established in the operation known as duodenopancreatectomy. Even with general employment of this operation, it is safe to assert that the great majority of patients with technically resectable cancers of the head of the pancreas and the duodenum are denied an opportunity for life because of the lack of surgical experience on the part of surgeons to whom they are entrusted, or the reluctance of these surgeons to undertake an operation of this magnitude. As an example of our own failure to think clearly, I would like to cite the following case history:

Case 4 C F, a woman of 50 years, had hematuria due to a clear-celled papillary adenocarcinoma of the right kidney. The usual nephrectomy was done in the Memorial Hospital, from which she convalesced without complications. Several months later, she left for a vacation in Europe, and while there, her family noticed a progressively increasing jaundice. By the time she returned to the Memorial Hospital, she had become emaciated due to an extremely rapid weight loss, was vomiting incessantly, had become deeply jaundiced, and a mass could be felt in the right hypochondrium. Barium feeding and roentgen-ray studies revealed an obstruction in the second part of the duodenum. Because of the recent history of right nephrectomy and the location of the present mass, a presumptive diagnosis of recurrent renal cancer was made with secondary involvement of the liver, duodenum, and pancreas. The condition was deemed inoperable and laparotomy was therefore not attempted. The patient died in the hospital, and a postmortem examination was secured. There was no evidence of recurrence of the renal cancer. A papillary carcinoma of the ampulla of Vater was found, causing practically complete obstruction of the bile ducts and almost complete obstruction of the duodenum. There was no evidence of metastasis from this second cancer, and it would have been a technically easy feat to have removed it by the classical Whipple operation. In this instance, the diagnosis of inoperability was in error, due to a biased opinion based on the previous history of a recent cancer of the kidney, and the failure on our part to consider the symptoms and physical findings as typical of an ampullary cancer.

C. COLON

We now know that the colon may be removed in its entirety, as is done in those patients with multiple or diffuse polyposis of the bowel or in those with multiple colonic cancers. Many cancers of the colon, particularly of the papillary type which are commonly infected, are adherent to adjacent organs. This does not constitute a state of inoperability because in the majority of cases, these neighboring viscera may be removed safely with the colon. For example, there have been numerous instances in which we have resected a large segment of the colon, combined with hysterectomy in the female, or a wide segment of the pelvic colon with partial cystectomy in the male, or the splenic flexure with an adherent spleen. In one instance, a right hemicolectomy was done with a resection of two loops of adjacent ileum to include large nodes in the adjacent mesentery, the pathologic diagnosis was reticulum cell

lymphosarcoma Multiple anastomoses were performed in a single-stage operation and the patient was living and well for eight years until she died of a heart attack A cancer of the transverse colon with an external fistula of six months' duration was resected with a large segment of the abdominal wall without difficulty There have been several cases in our series with the transverse colon adherent to the stomach, and in some instances, with perforation and fistula formation so that colectomy was combined with subtotal gastrectomy in order to remove the cancer in toto

D RECTUM

Many errors are made in diagnosing a rectal cancer as technically inoperable because of fixation as judged by digital examination of the cancer through the rectum Many cancers which appear to be firmly adherent in the hollow of the sacrum or to the lateral wall of the pelvis when felt by combined recto-abdominal palpation can be successfully removed at the time of laparotomy Unless the cancer is completely fixed to cause the so-called frozen pelvis, and providing the patient does not have evidence of distant metastases in the liver or in signal nodes, these patients profitably may be explored This sometimes results in the happy discovery that the adherence of the cancer is a pseudo-fixation that can readily be relieved by dissection Cancers of the rectum, because of their tendency to infection and extension through the wall of the bowel, become adherent to adjacent pelvic viscera such as the urinary bladder or the uterus Under these circumstances, these organs should be removed in part or in whole, depending upon the extent and particular site of involvement Three brief case histories are appended here to illustrate the plan of procedure under these conditions

Case 1 K D, a 71-year-old woman, had a bulky adenocarcinoma of the rectum filling almost the entire ampulla and invading the rectovaginal septum It had perforated into the vagina, which was filled with a fungating sphacelate tumor The entire perineum and perineal body were infiltrated by cancer We performed an abdomino-perineal rectal resection associated with a vaginectomy The vaginal mucosa overlying the base of the bladder was left intact, but the remainder of the vagina was removed with the rectum Convalescence was uneventful This same operation of rectal resection and vaginectomy, sometimes with an associated hysterectomy, has been done at least five or six times

Case 2 B K, a woman 56 years of age, had a carcinoma of the rectosigmoid A previous supracervical hysterectomy had been performed The cancer had become adherent to and invaded the urinary bladder A superior segmental resection of the carcinoma was performed, together with a subtotal cystectomy The operation was completed by an end-to-end anastomosis of colon and rectum Convalescence was uneventful

Case 3 M S, a woman 54 years of age, was admitted to the hospital in a state of shock due to recent multiple hemorrhages which had been almost exsanguinating A huge tumor was found to occupy the rectum, involving the rectovaginal septum, the posterior fornix and adherent to the cervix and uterine isthmus A biopsy was reported as leiomyosarcoma The terminal portion of the rectum was uninvolved by the tumor An abdomino-perineal rectal resection was performed, together with a radical pan-hysterectomy and vaginectomy The rectal sphincter was preserved, and the entire rectum was removed by reaming out the mucosa from the sphincter, after which the sigmoid

colon was brought down through the pelvis and hollow of the sacrum to protrude through the dilated sphincter. Healing occurred by primary union, and the patient was discharged from the hospital within two and one-half weeks. The function of the sphincter soon returned, and she was able to have normal bowel movements by rectum.

E VAGINA

General surgeons and gastro-intestinal surgeons operating on cancers of the rectum have, on many occasions, performed a partial vaginectomy, together with an abdomino-perineal rectal resection for those rectal cancers that involve the rectovaginal septum. This has been an accepted mode of procedure. Gynecologists, on the other hand, and almost without exception, have been prone to classify all vaginal cancers as inoperable. The case of inoperability has even been listed on the patient's chart as due to invasion of the rectovaginal septum, with the statement that vaginectomy could not be done without entering the rectum. From the patient's point of view, a death from cancer of the vagina is just as bad as death from rectal cancer, and a permanent terminal abdominal colostomy for cancer of the vagina should be just as acceptable as it is for cancer of the rectum. On two occasions in which vaginal cancers were involving the posterior vaginal wall and posterior fornix, we have performed the operation of abdomino-perineal rectal resection with vaginectomy. If these vaginal cancers are infiltrating, and many of them are, there should be no hesitation in removing the rectum, even though it entails a permanent colostomy.

F PROSTATE

The radical operation for cancer of the prostate as originated by Dr. Hugh Young has found some acceptance for those prostatic cancers that are removable. Total cystectomy for cancers of the urinary bladder is being done much more frequently in conjunction with bilateral uretero-sigmoidostomy. An example of the extension of radical surgery for cancer ordinarily classified as inoperable may be given in the following case report.

S. L., a Greek-American, 58 years of age, had been in excellent health without complaints until only two months prior to hospital admission. Since that time, he had had some frequency and urgency of urination, but the chief complaint was progressive constipation and later the passage of mucus and blood in his stools. At the time of admission, he had complete rectal obstruction with great abdominal distention. On digital examination, the ampullary portion of the rectum was completely obstructed by a firm mass, a biopsy of which revealed adenocarcinoma of undetermined histogenesis. The blood urea nitrogen was 87 mg percent, and the patient was in a state of uremia. The situation was critical, but an immediate transverse colostomy was performed in order to relieve the intestinal obstruction. This was followed in a few days by a bilateral external ureterostomy by Dr. Archie Dean. After the blood urea nitrogen had returned to normal and the patient's condition had been greatly improved by blood transfusions and the institution of proper diet, a third operation was performed, which was of radical character. The terminal segments of the ureter, the entire urinary bladder, the prostate, the pelvic colon, the rectum, and the perineum were removed in continuity and entirely. The operation practically consisted of an exenteration of the true pelvis. So much peritoneum was removed with the specimen that the pelvic floor could not be reconstructed, so the principle of a Coffey dam with packing below was employed. The cancer was found to be primary in the prostate, and it practically replaced the entire organ.

The cancer had extended secondarily to involve the adjacent rectum and completely occlude it. It also infiltrated into the base of the urinary bladder and involved the entire bladder with bilateral obstruction of the ureteral orifices. The convalescence was protracted, due to the huge space left after ablation of these organs, but no serious complications occurred, and he was discharged from the hospital in good health.

G TUMORS PRIMARY IN OR ADHERENT TO THE BONY PELVIS

The involvement of the os innominatum, with the exception of the iliac crest, by a primary malignant tumor of bone had in the past almost invariably been considered as inoperable. Furthermore, cancers primary on the lower extremities, such as synoviomias, malignant melanomas, and epitheliomas, after metastasis to the groin and extension into the iliac nodes with adherence, were deemed inoperable because of the extent of the disease. Primary malignant bone tumors of the pelvic bone and tumors in the region of the buttock, such as sarcomas of the soft somatic tissues that are adherent, and metastasizing melanomas and epitheliomas that involve the iliac nodes with adherence, are now being treated by such a radical procedure as hemipelvectomy, or the so-called interilio-abdominal amputation. We have performed a series of ten hemipelvectomies at the Memorial Hospital, based on these indications, without an operative death.

H MALIGNANT TUMORS OF THE ORAL CAVITY AND ADJACENT SINUSES

The same principle of radical surgery is now being applied for the treatment of cancers that develop in the head and neck, particularly those involving the mucous membranes. Examples of the surgical treatment of cancers previously deemed inoperable are cited in the two following case reports.

Case 1 A S, a 19-year-old boy, came to the Lendrum Tumor Clinic of the Paterson General Hospital with a huge osteochondrosarcoma involving the left maxillary antrum. The tumor had extended into the orbit with destruction of the orbital plate and caused protrusion of the eyeball with diplopia. It had eroded away the medial wall of the antrum and was fungating with obstruction into the left nasal chamber. It spread through the external wall with marked extrusion of the cheek. It had destroyed the floor of the antrum and the roof of the mouth and was perforating into the mouth, through the hard palate, and the left superior gingivo-buccal gutter. After bilateral ligation of the external carotid arteries, the classical Hautant-Monod exposure was obtained by incising through the philtrum of the upper lip and along the naso-malar fold and the margin of the left lower eyelid with retraction of the skin and subcutaneous flaps laterally. The entire left superior maxilla with the major portion of the roof of the mouth, the zygoma, the floor of the orbit, and the lateral aspect of the nasal chamber were then surgically completely removed. The tumor proved to be an osteochondrosarcoma. His convalescence was uncomplicated, and the defect in the roof of his mouth was corrected by an obturator attached to a superior dental plate. The floor of the orbit was replaced by a temporal muscle transplant to serve as a hammock. The eyeball resumed its normal position and vision was undisturbed. Fourteen years have elapsed since the operation. The patient is living and well, has graduated from college, and is a religious teacher.

Case 2 A T, a Hindu, came from Bombay in a very weakened condition due to extreme pain and inanition secondary to an advanced cancer of the tongue. This carcinoma involved the entire left side of the tongue, extending from the tip to the vallecula, and infiltrating deeply to the middle of the tongue. The carcinoma involved the entire left side of the floor of the mouth and was adherent to and invading the horizontal

ramus of the left mandible. It extended onto the region of the left tonsil and tonsillar pillars and caused trismus so great that the jaw could not be opened. Firm lymph nodes in the left submaxillary region were replaced by metastatic carcinoma and were inseparably adherent to the under surface of the mandibular ramus. Other lymph nodes were present in the left digastric group. He was admitted to the Doctors Hospital, where under intratracheal anesthesia, the left lip was bisected and the skin flaps turned widely back in continuity with a Bastianelli incision for radical neck dissection. The dissection of the left neck was accompanied by ligation of the external carotid artery. The lymph nodes in the left submaxillary region were so firmly adherent to the mandible and to the underlying muscles that all of the structures of the submaxillary triangle were removed, together with the hyoid bone to which the carcinomatous nodes were adherent. The mandible was severed through the mental process. The left side of the mandible, together with the entire floor of the mouth and the left lateral two-thirds of the tongue, was then completely severed in the anterior posterior direction. The mandible was then disarticulated at the temporomandibular joint, and the base of the tongue, together with the tonsil and tonsillar pillars and the left side of the oral pharynx, were dissected down to the pterygoid fossa. The mucous membrane of the left cheek along the gingivo-buccal gutter was then approximated to the lateral aspect of the severed tongue, and the skin flaps were also approximated by a plastic procedure. The operation was terminated by a tracheostomy. The patient was out of bed 24 hours after the operation and was fed for two weeks by means of a nasal catheter. At the time the tracheostomy tube was removed, he was able to swallow food by mouth, the mouth was fairly well healed, and his voice was quite satisfactory except for lingual sounds.

SUCCESSFUL SECONDARY OPERATIONS FOR CANCER

The surgeon is frequently confronted with patients and their relatives who relate the story of exploratory laparotomy followed by a pronouncement of inoperability and, in consequence, incurability of the cancer. They usually importune the next surgeon seen, and perhaps many others, to intervene again, not being willing to accept the opinion and judgment of the initial surgeon, who had an opportunity to study the extent of the cancer at the time of laparotomy. Physical examination of such patients, after their discharge from other hospitals, may often permit the later surgical consultant to agree in the obvious diagnosis of inoperability. However, in the absence of physical signs of inoperability, one is sometimes justified in sending a note of inquiry to the surgeon, requesting a copy of the operative findings. If the reasons for not resecting the cancer were given as distant metastases, for example, in the liver, or diffuse peritoneal carcinosis, then the indications of inoperability must be considered absolute. But if the operative findings are listed, indicating that the decision not to remove the cancer was based on technical difficulties, there may exist a suitable excuse for a second attempt at removal. It may seem presumptuous to attempt an operation in the face of a previous failure by one who has had an opportunity to inspect the cancer and its extent at the time of laparotomy, but in some of the following case reports, the wisdom of this decision seems apparent. Such secondary operations should be taken with a full understanding by the family that it might not be possible to complete the operation successfully.

1 *Stomach Interval before Secondary Resection—27 months*—R. B., a 39 year-old man, came to the Gastric Clinic of the Memorial Hospital with the story that two years

and three months before, he had been subjected to a laparotomy for a gastric cancer, which was found to be inoperable. The story seemed incredible because, in our experience, the average patient with inoperable gastric cancer is dead within a year after the date of the diagnosis. A letter was dispatched to the hospital for a loan of the slide of the biopsy. The slide revealed an adenocarcinoma, and the date of the biopsy was two years and three months previous, agreeing with the patient's statement. The surgeon's report classified the cancer as inoperable because it originated in the fundus of the stomach and was extending into the esophagus above the level of the diaphragm. Because careful physical examination did not reveal any evidence of distant dissemination of the cancer and because the patient seemed to be in good health, he was accepted for treatment in the Clinic. Gastro-intestinal roentgenogram studies revealed a huge tumor occupying the fundus and cardiac end of the stomach with extension for several centimeters into the esophagus well above the level of the diaphragm. A preliminary laparotomy was done for purposes of exploration. There were no metastases in the liver, the tumor although bulky was movable, and it was therefore possible to remove it by the combined thoracic and abdominal approach. The exploratory operation was terminated by a jejunostomy for feeding purposes. Two weeks later, a thoracotomy was performed and the diaphragm severed. The distal segment of the esophagus was removed and the major portion of the stomach. There was not sufficient stomach left for esophago-gastrostomy. Since the remnant of esophagus was high under the aortic arch, one could not bring up a loop of jejunum to construct an intra-thoracic esophago-jejunostomy, particularly because a jejunostomy had been performed, and the operation had to be completed quickly. The esophagus was then brought out through the neck and onto the chest wall to construct an anterior thoracic esophagostomy. At a later date, the remnant of the stomach was brought to the anterior wall for a gastrostomy opening. The patient convalesced from these operations without complications. The significance of this case record is that it was still possible, by the transthoracic approach, successfully to resect the lower portion of the esophagus and the major part of the stomach for a cancer which had been diagnosed as inoperable in another hospital two years and three months prior to this date.

2 *Stomach Interval Before Secondary Resection—3 months*—J Z, a 58-year-old janitor, was operated on at the Memorial Hospital for cancer involving the distal segment of the stomach. Because the cancer had perforated through the serosa and because of its fixation to the pancreas, it was classified as inoperable and a gastro-jejunostomy was performed. When the attending surgeon left for a protracted European vacation three months later, the resident surgeon who had participated in the operation and disagreed in the opinion of inoperability, readmitted this clinic patient and then performed a gastric resection, removing the distal segment of the stomach below the site of the original gastro-jejunostomy. This patient is now living and well 16 years after the gastric resection. The gastric resection was done three months after the attending surgeon had classified the cancer as inoperable.

3 *Cecum Interval Before Secondary Resection—9 months*—R K, a man 42 years of age, had a laparotomy nine months before for cancer of the cecum. The cancer was diagnosed as inoperable because of apparent metastases involving lymph nodes in the mesocolon, these lymph nodes were said to be quite large and firm, but none was removed for microscopical study. The surgeon also observed numerous white nodules on the peritoneum in the mesentery of the small bowel and adjacent to the cecum and large intestine, these were interpreted as representing nodules of metastatic cancer. No microscopical study or confirmation of the diagnosis was made. Inasmuch as the patient, nine months later, did not have ascites nor an enlarged liver and was not greatly worse except for a progressive anemia, he was brought to New York City. At the Memorial Hospital, a second laparotomy was performed, and it was found possible to perform a right hemicolectomy with an anastomosis between the terminal ileum and transverse colon. The white peritoneal nodules previously described were no longer apparent and the enlarged

lymph nodes had subsided, which would lead one to infer that they were involved by inflammatory lymphadenitis, rather than by metastatic cancer

4 *Duodenum Interval Before Secondary Resection—7 months*—S H, a young Naval officer, vomited a huge quantity of blood while in the Pacific Zone. A diagnosis of duodenal ulcer was made, and he was placed on a hospital ship and later returned to the United States. Several episodes of hematemesis occurred. Roentgen-ray studies were made on two occasions with a diagnosis of duodenal ulcer. Finally, four months after the onset of symptoms, and because of the occurrence of jaundice, a laparotomy was performed. A tumor was palpated in the region of the head of the pancreas, and a diagnosis of inoperable cancer was made, the operation was terminated by a cholecystojejunostomy.

Seven months after this operation had been performed, during which time the patient had not been informed as to the character of his illness, he was admitted to the Memorial Hospital. The early roentgen-ray films were obtained and they clearly showed the presence of a tumor in the second part of the duodenum. The diagnosis of carcinoma of the ampulla of Vater was made and a second laparotomy advised. After exploration, the classical pancreaticoduodenectomy was performed. The cholecystojejunostomy was left intact, but the common bile duct was also used to perform a choledochojejunostomy. The distal end of the severed stomach was implanted in the descending jejunal loop. The patient had an uneventful convalescence. The tumor proved to be a papillary adenocarcinoma of the ampulla of Vater.

5 *Duodenum Interval Before Secondary Resection—30 months*—J C, a man 45 years of age, came to the Memorial Hospital two and one-half years after he had been operated upon in another institution where a diagnosis of inoperable cancer of the pancreas was made. At the time of the first laparotomy, a cholecystgastrostomy was done. This relieved his jaundice, and he was in comparative comfort for more than a year. The cholecystgastrostomy stoma apparently did not function well, so after a second laparotomy a cholecystojejunostomy was done. One year later, due to obstruction of the duodenum by cancer, a third laparotomy was performed, at which time a gastro-jejunostomy was done. At this last operation the surgeon, who was not the one previously engaged, made a thorough exploration of the abdomen and observed that the cancer had not metastasized to the liver and that it was movable, though bulky. As a result of his findings, he advocated a fourth laparotomy which was done on the Gastric Service of the Memorial Hospital. We were able to perform the usual pancreaticoduodenectomy and completed the operation by imbedding the common bile duct in the jejunum for a choledochojejunostomy. The carcinoma was an infiltrating cancer involving the ampulla of Vater and the head of the pancreas. Convalescence was uneventful. The patient is now living and well two years after the successful resection. The unusual feature of this case report lies in the fact that the first actual attempt at resection of this cancer was on the occasion of the fourth laparotomy.

6 *Rectum Interval Before Secondary Resection—4 months*—A W, a 41-year-old woman, entered the hospital with a large carcinoma of the rectum which appeared moderately fixed on recto-abdominal palpation. Four months before, a laparotomy had been performed at another hospital, at which time the cancer was considered inoperable because of local technical difficulties. The operative notes at that time indicated that there was no evidence of distant dissemination and no evidence of metastasis in the liver. Two months later, the patient entered another hospital where a second laparotomy was performed by another surgeon. He also classified the rectal cancer as inoperable and performed a simple loop colostomy. When we examined the patient, we found a functioning sigmoid colostomy. There was a large carcinoma completely encircling the lumen of the bowel in the upper rectal ampulla, it was moderately fixed to the pelvic wall. As there was no palpable enlargement of the liver, we decided to attempt a resection. Accordingly, a laparotomy was done and it was found possible to perform an abdomino-perineal rectal resection. The patient convalesced from this operation without complications. The state-

ments of the two previous surgeons concerning the inoperability of the cancer were based, therefore, solely on technical difficulties, rather than on the actual stage of the disease

7 *Retroperitoneal Sarcoma Interval Before Secondary Resection—6 weeks*—R L, a 5 months old infant, was admitted to the Children's Ward of the Memorial Hospital with a huge tumor in the left iliac quadrant Six weeks before, an operation had been performed in another institution, at which time the location of the tumor was thought to be retroperitoneal and beneath the mesentery of the colon It was considered inoperable and a biopsy only was obtained, which was reported as a sarcoma We subjected the child to a laparotomy and after careful dissection, were able to remove the retroperitoneal sarcoma and preserve the integrity of the overlying intestines It was diagnosed as a rhabdomyosarcoma of embryonal type There was no evidence of metastasis of this sarcoma Again, in this instance, the diagnosis of inoperability was based solely on technical difficulty, and the dissection was not attempted because of this fact, although it was obvious that the child would die of the sarcoma

SUMMARY

The definition of inoperability of cancer has an important influence on end results The point of view of the surgeon plays a significant role in determining whether or not a given patient should be subjected to operation and attempt at surgical removal of the cancer A distinction should be made between *absolute* inoperability due to distant dissemination of the cancer and obvious incurability, and *relative* inoperability due to local technical difficulties No surgeon should perform an exploratory operation unless he is qualified to proceed with the actual removal of the tumor if encountered Excisional surgery should be available for cancer patients of advanced age if they can be prepared for such an ordeal, as old age alone is not a sufficient excuse to deny these patients the only opportunity to overcome an otherwise fatal disease The condition of the patient may present seemingly serious hazards from the surgeon's viewpoint, but with the current improvement in preoperative and postoperative management, the dangers are often reduced to the point where major surgical procedures may be safely performed The stage and extent of the cancer complicate the judgment of the surgeon, but if the cancer is removed whenever technically possible, occasional cures are surprisingly obtained Palliative resections of the stomach, colon, and rectum afford a great deal of relief to many patients even though small metastatic foci are detected in the liver Involvement of multiple organs by cancer has been given as a reason for inoperability, but one should attempt by every means possible to remove such cancers which are adherent to any adjacent structures or viscera that may be sacrificed by excision in continuity with the organ involved Some patients who have had exploratory laparotomy for cancer with abandonment of the operation and pronouncement of incurability are entitled to another chance or effort by a different surgeon if the former surgeon classified the cancer as inoperable because of technical difficulties Case reports are inserted to illustrate the arguments throughout this thesis

THE SURGICAL TREATMENT OF THE INFANTILE TYPE OF COARCTATION OF THE AORTA

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COARCTATION OF THE AORTA may be divided into two types according to the classification of Bonnet¹ In the *infantile type* there is an elongated narrowing of the aorta at the isthmus while in the *adult type* there is an abrupt constriction at or near the ductus arteriosus Maude Abbott² found records of 237 cases of coarctation of the aorta which came to autopsy, of which 155 were of the adult type and 82 were of the infantile type She found that the infantile type was frequently associated with other congenital anomalies which contributed to the early death of the patient In a later report she³ noted that in 200 cases of the adult type which came to autopsy, the associated hypertension was the chief cause of death The average age was 33 years Of these, 39 died as the result of spontaneous rupture of the aorta or heart, 26 had cerebrovascular accidents, and 67 died of myocardial failure Thus 66 per cent died at this early age as the result of the associated hypertension This would seem to constitute sufficient cause for attempting to correct the congenital defect by surgical means

The first operation performed for coarctation of the aorta was done by Crafoord⁴ of Stockholm on October 19, 1944 He reported two successful operations on the adult type in which the constricted area was excised and the two ends of the aorta sufficiently mobilized to bring them together and do an end-to-end anastomosis The Carrel suture technic was used By June 1946 Crafoord⁵ had operated upon seven patients of the adult type and was able to excise the short segment and do an end-to-end anastomosis in all of them

Blalock and Park⁶ and Gross and Hufnagel⁷ had previously reported experimental work in dogs concerning this problem Blalock had shown that the left subclavian artery might be brought down and anastomosed to the side of the aorta below the coarctation Gross had shown that a segment of the dog's aorta could be excised and an end-to-end anastomosis done

Gross⁸ operated upon his first patient a short time after Crafoord and Nylin⁴ and used the continuous everting mattress suture which he had used in experimental animals By June 8, 1947 he⁹ had operated upon 23 patients with only two deaths The anastomosis was completed in 20 of the patients There was so much inflammatory change present in one patient that the aorta could not be safely mobilized The remaining two patients had lesions of the

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A



B

FIG 1—(A) Case 1 The infantile type of coarctative of the aorta. The stenotic area was long and the lumen of the vessel was completely obliterated. It was estimated 40 to 50 cm. of aorta would have to be excised preparatory to an anastomosis. Note the large first intercostal artery.

(B) The large left subclavian artery was divided, rotated downward and sutured to the end of the descending aorta.

infantile type, with such long areas of constriction that it would have been impossible to bring the ends of the aorta together had the constricted areas been resected. Gross considered these two patients inoperable. As of his last report Crafoord⁵ had encountered none of the infantile type of coarctation.

We have recently operated upon three patients with coarctation of the aorta of the infantile type. In all three instances the constricted area extended over a distance of several centimeters. It was obviously impossible to perform the type of operation used by Crafoord or Gross. However, it seemed worth while to turn the left subclavian artery down to bridge the defect. In two patients the end of the subclavian artery was anastomosed to the upper end of the descending aorta after the area of the defect had been excised. In the third patient the operation had to be abandoned because of the friability of the vessels due to atheromatous changes.

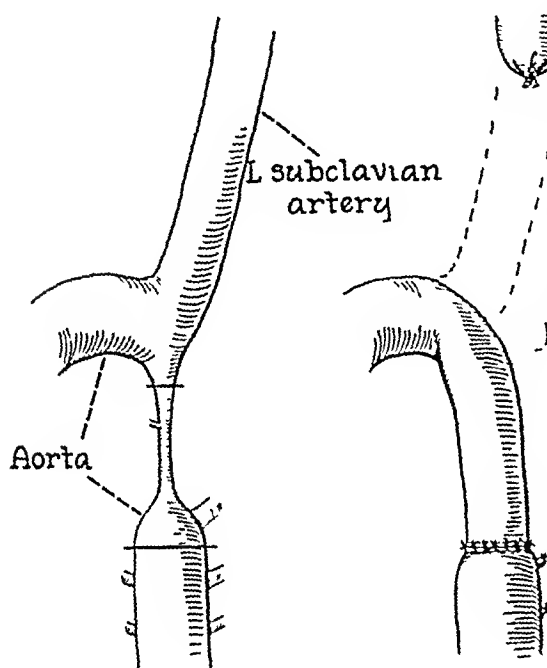


FIG 1—(C) A diagram of the procedure. The anastomosis was done, with a continuous everting mattress suture and with a few reinforcing interrupted sutures.

Case No 1 V B, a 13-year-old negro boy, was first seen by Doctor Rachel Ash at the Children's Hospital in July 1942, complaining of dyspnea and precordial pain on exertion. He had a blood pressure of 150/110 and a soft blowing systolic murmur in the first and second interspaces to the left of the sternum. On roentgen-ray examination a small aortic knob and indentation of the inferior borders of several ribs were seen. The femoral and dorsalis pedis pulses were barely palpable. A diagnosis of coarctation of the aorta was made. In subsequent follow-up studies the weak pulses in the lower extremities disappeared completely.

Upon admission to the Hospital of the University of Pennsylvania on January 6, 1947, the boy appeared to be normal mentally and physically except for the above findings. He was symptom free except upon strenuous exertion. He weighed 90 pounds. The blood pressure was 160/110 in both arms. It was unobtainable in the legs. No pulse was palpable in the abdomen or lower extremities. The cold persor test showed a rise to 220/150 in 30 seconds. Studies of blood flow by the ballistocardiograph and studies of renal blood flow were made pre- and postoperatively*.

Studies of renal blood flow showed a significant increase in Case No 1 with an increase of a magnitude not great enough to be significant in Case No 2.

EFFECTIVE RENAL BLOOD FLOW			
	January 16	January 29	May 16
Case No 1	880 cc/min	1130 cc/min	1080 cc/min
	February 19	April 26	
Case No 2	1120 cc/min	1200 cc/min	

The blood flow was calculated from para-amino hippurate clearance and hematocrit readings. These tests were done by Doctors J. K. Clark, G. J. Gislason and H. G. Barker and will be reported in detail elsewhere.

* Studies of blood flow by the ballistocardiograph in Cases 1 and 2 indicated an increase in blood flow in both patients following operation.

A



B

FIG 2—(A) Case 2 In this patient there was a small lumen in the coarctation, but the area of significant decrease in diameter was about 40 to 50 cm long

(B) The left subclavian artery was rotated downward and sutured to the end of the descending aorta

The patient was operated upon on January 17, 1947 under endotracheal cyclopropane anesthesia. With the patient on his right side the left fifth rib and short segments of the fourth and sixth ribs were resected. The coarctation of the aorta was recognized as being infantile in type with a stenotic area 40 to 50 centimeters in length, as shown in the accompanying photograph and diagram. The aorta was freely mobilized by dividing

5 intercostal arteries, but it was obvious that the ends of the aorta could not be brought together for an anastomosis if the stenosed segment were excised. The left subclavian artery was found to be quite large. It seemed reasonable, therefore, to divide the subclavian artery, rotate it downward and anastomose it to the descending aorta as Blalock and Park⁶ had done experimentally in dogs. The aorta was ligated and divided. Its lumen was found to have been completely obliterated at the site of greatest narrowing.

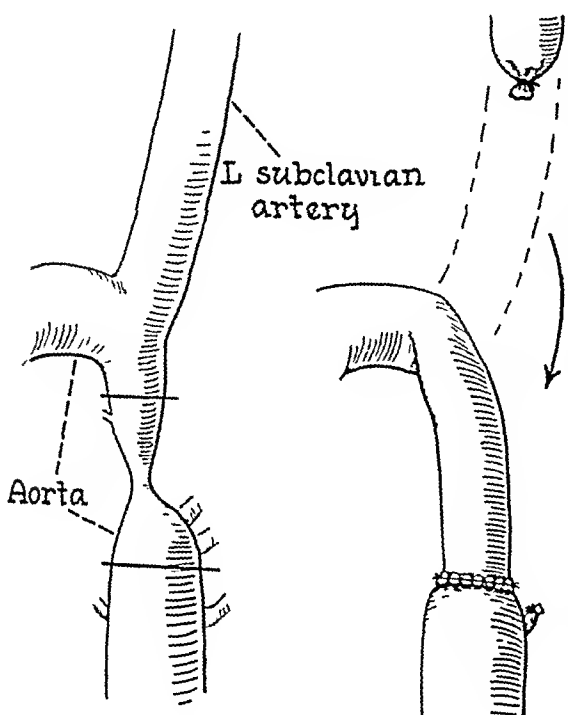


FIG 2—(C) A continuous evertting mattress suture was used, but because of the difference in the size of the vessels, several interrupted sutures were placed at the site of buckling.

Since the subclavian artery was almost as large as the descending aorta an end-to-end anastomosis was done without difficulty, using the evertting mattress suture as described by Cross and Hufnagel.⁷ Crafoord clamps covered with white shoe strings were used to occlude the aorta. The clamps were gradually removed over a period of three minutes with no change in the patient's condition. It was immediately possible to feel bounding pulses in both feet. The patient's postoperative course was uneventful. He was allowed to be out of bed on the first postoperative day and began to walk on the fifth postoperative day. The blood pressure came down slowly. Between the tenth and twentieth post-operative days the blood pressure in the right arm averaged 120/80 and in the legs 110/70. The child was discharged on the twenty-first day feeling entirely well.

He was re-examined on the thirteenth of November 1947, 10 months after operation. He had gained 22 pounds in weight and 35 inches in height since operation. The blood pressure in the right arm was 115/70 and in the legs was 105/65. He had good pulses

in both feet. A soft blowing systolic murmur was still present to the left of the sternum in the second interspace. The patient stated that he felt perfectly well and had no symptoms of any sort during strenuous exercise.

Case No 2 C I, a 17 year old boy, was rejected for military service in April 1946 because of high blood pressure. His only complaint was that when participating in high school track he could not run the mile even after much practice. He was first studied in the Cardiac Clinic and then admitted to the Hospital of the University of Pennsylvania on the sixteenth of February 1947. He weighed 120 pounds and appeared to be in good condition. The blood pressure in his arms was 160/90 and was unobtainable in his legs. No pulses were palpable in the lower extremities. A harsh mid systolic murmur was heard best in the second and third interspaces to the left of the sternum and also along the vertebral border of the left scapula. By fluoroscopy the heart was normal in size, and the aortic knob was not visible. There was notching of the fourth and fifth ribs. A diagnosis of coarctation of the aorta was made. Studies of blood flow by the ballistocardiograph and studies of the renal blood flow were made before and after operation.* During the cold pressor test the blood pressure did not rise appreciably. During the sodium amytal test the blood pressure fell to 130/90.

The patient was operated upon on February 26, 1947. The same approach was used as in Case No 1. The coarctation was found to be infantile in type (see photograph and diagram). It was not complete but extended over a distance of 45 to 50 centimeters.

* Refer to footnote on page 1121

An effort was made to preserve the intercostal arteries as suggested by Crafoord,⁷ but in so doing one was torn and considerable difficulty was encountered in controlling the hemorrhage. Finally 6 arteries were divided in order adequately to mobilize the aorta. As may be seen by the photographs, the subclavian artery was not as large in proportion to the aorta as in the first patient, but it was divided and the proximal end rotated downward and anastomosed to the end of the aorta. When the clamps were removed, a moderate pulse could be felt immediately in both lower extremities. The postoperative course was uneventful. The pulses in the legs seemed weaker 2 or 3 days after operation than on the day of operation. After 3 weeks the blood pressure had changed from an average of 160/90 to 160/70. The patient was discharged symptom free on the twenty-second day.

Upon readmission on the twenty-fourth of April 1947 the pulses in the lower extremities seemed stronger than upon discharge. The blood pressure in the right arm was 160/70 and in the legs was 120/95. The patient is still symptom free. He has no drop in his systolic pressure, but the diastolic pressure in his upper extremity has returned to normal.



FIG 3—Case 3. The lumen of his aorta was completely obliterated at the point of greatest narrowing. The length of the stenosed area, which was smaller than the left subclavian artery, was measured to be 50 centimeters.

Case No 3. S. S., a 20-year-old boy, was rejected by the army because of hypertension. For the last 2 or 3 years he had been having increasing dyspnea upon exertion. Finally this became so severe that he could not hold a job. He weighed 120 pounds. His blood pressure varied between 220/120 and 260/120. Roentgen-ray examination showed an absence of the aortic knob and indentation of the inferior border of several ribs. No pulses were palpable in the lower extremities.

A diagnosis of coarctation of the aorta was made and operation advised. The operation was performed by the same approach as in the two previous cases. The coarctation was found to be infantile in type. It was 50 centimeters in length by actual measurement. It was decided to attempt the same procedure as used in the first 2 cases. We were first aware that we might be in trouble when we divided the subclavian artery and found the inside yellow with atheromatous plaques, and when we attempted ligation of the coarcted area of the aorta, the ligature cut through. The subclavian artery was

not as long as in the 2 previous patients. It appeared that some slight tension was present as the two vessels were approximated. Although the tension seemed very mild, the subclavian artery ruptured at the site of an atheromatous plaque fairly close to the aorta. When a clamp was applied across the subclavian artery to control the massive hemorrhage, it cut partly through the vessel wall. A heavy silk ligature placed proximal to the clamp also cut partly through the wall, but a No. 2 chromic catgut ligature placed further proximally controlled the bleeding satisfactorily at the time. A suture ligature was placed distal to it. The operation was abandoned. The blood pressure had fallen during the operation, but 12 hours after operation his blood pressure reached the preoperative level of 260/120, and he suddenly succumbed. Autopsy showed that the subclavian artery had torn through at the site of the most proximal ligature. The entire aorta and the great vessels above the coarctation were extensively covered with atheromatous plaques, and all were very friable.

COMMENT

In the infantile type of coarctation of the aorta excision of the area and end-to-end anastomosis will probably never be feasible. Gross in two instances has considered this type inoperable. If the subclavian artery is to be used for the anastomosis, as was done here, the question will always arise as to whether the blood flow is materially increased by the procedure. In Case No. 1 no blood was going through the coarctation, but five intercostals were divided. It is evident, however, that this patient was improved. A bounding pulse was present in his lower extremities, and the blood pressure in the upper extremities returned to normal. In Case No. 2, however, some blood was going through the coarctation. Not only this was sacrificed, but also 6 intercostal vessels. It is, of course, questionable whether the subclavian artery delivered more blood flow to the descending aorta than was sacrificed. The presence of palpable pulses in the lower extremities postoperatively suggests some increase in blood flow. That the increase was not adequate is indicated by the failure of the systolic blood pressure to return to normal although there was some fall in the diastolic pressure.

Although Gross⁹ had previously pointed out the hazard of operating upon patients in the older age group, we felt that we were justified in attempting Case No. 3 at the age of 20 inasmuch as Crafoord⁵ had been successful in several patients of this age group. The difficulty here lay in not being able to recognize until it was too late that the vessels were too friable to be worked with. Perhaps the preoperative blood pressure of 260/120 should have been sufficient warning to us. With the chest open and the vessels exposed it was still impossible for us to ascertain the true condition of the vessel walls until after the vessel had been cut across and the atheromatous changes visualized. If this information could be obtained without actually opening the vessel, the difficulties encountered in Case No. 3 might be avoided by abandoning the operation before sacrificing any of the blood flow already present.

The problem arises as to the age to elect to operate upon the patient with coarctation of the aorta. If it is done too early, there is some question as to whether the site of anastomosis will grow with the patient. If it is done too

late, the vessel wall may be so friable as to make the suture hazardous. It would seem that 12 to 14 years of age would be the most satisfactory time

SUMMARY

1 Three patients (age 13, 17 and 20) with the infantile type of coarctation of the aorta were operated upon

2 In two patients the subclavian artery was divided, and rotated downward to bridge the defect by an end-to-end anastomosis with the descending aorta. In a third patient the operation had to be abandoned because of the atheromatous condition of the vessel walls, and the patient succumbed from hemorrhage in the immediate postoperative period

3 The first patient obtained a good result with the blood pressure in the upper extremities returning to normal. The second patient's systolic blood pressure did not fall although the diastolic pressure returned to normal

4 We believe that the use of the subclavian artery to bridge the gap in the infantile type of coarctation of the aorta is worthy of further trial in selected cases

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BATTLE WOUNDS AND INJURIES OF THE HEART AND PERICARDIUM

Experiences in Forward Hospitals

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SEVENTY-FIVE PATIENTS with wounds of the heart or pericardium were cared for by surgeons of the Second Auxiliary Surgical Group in Field and Evacuation hospitals. This is an incidence of 3.3 per cent in the group of patients with thoracic and thoracic-abdominal injuries (total of 2,267 cases) whose initial surgery was performed by surgeons of the unit. Fifty-seven per cent (43 cases) occurred in patients whose wounds involved the thorax only. One of the 75 injuries was due to a self-inflicted stab wound and the remainder were battle-incurred. Fifty-three soldiers were wounded by shell fragments and 21 by small arms fire. There were 18 examples of wounds of the pericardium only and 57 patients had traumatic lesions of the heart itself.

The following report is based on the writer's personal experience and on a careful review of all additional records in the files of the unit. This was supplemented in most instances by personal contact with each operating surgeon.

DIAGNOSIS

It was not always easy to diagnose cardiac wounds and injuries in forward hospitals. Electrocardiograms were not available and roentgenograms were limited for the most part to frontal and lateral films. Fluoroscopy was used to some extent but could have been employed more frequently. In slightly more than 50 per cent of all cases the actual cardiac wound was undiagnosed prior to commencing surgery. The thorax was opened in the majority of these because of probable thoracic-abdominal involvement, or for the debridement of large sucking wounds. In seven cases, suspected intrathoracic hemorrhage prompted exploration. In three cases, the presence of a foreign body in the mediastinum was an indication. In 15 cases (including two patients who died in the shock ward), the cardiac wound was discovered at autopsy.

In confirming the presence of cardiac injury, one finding alone is seldom conclusive (Table I).

Frequently a cardiac wound may be suspected by thorough physical examination and accurate localization of external wounds. Plotting of the missile track often can be done when examination is combined with roentgen studies showing the location of foreign bodies and the site of fractured ribs. When the foreign body is in, or in the region of, the heart, it may appear fuzzy or double-contoured. When localizing missiles within the cardiac shadow, heavy penetration must be used either by means of "bone technic" or the Potter-Bucky diaphragm. Often a missile will be completely over-

looked in a thoracic film of usual exposure. Fluoroscopy may be used frequently to study the motion of the missile and whether or not it is included within the cardiac shadow in all projections. The size and shape of the cardiac shadow may be altered and has been described as "water-bottle," fuzzy, or enlarged. The latter interpretation may be subject to question since the pericardium usually does not stretch appreciably when intrapericardial fluid first develops. In two cases where the cardiac outline was blurred or fuzzy on the roentgen film, operation disclosed considerable hemorrhage into the pericardial membrane and the areolar tissue of the lower mediastinum.

Signs of anoxia may be present in patients with cardiac wounds. Before attributing these signs to a cardiac lesion care must be exercised in eliminating other causes of oxygen want, such as extensive peritoneal contamination,

TABLE I—*Signs and Symptoms Suggesting Cardiac Lesions* *

Suspicion from course of missile	22
Roentgen evidence	
Foreign body in region of heart (4, labeled fuzzy or double contoured)	8
Foreign body suspected in region of heart, not proved	2
Alterations in size or shape of cardiac shadow	5
Symptoms due to anoxia	
Dyspnea	6
Necessity for early and continuous oxygen administration	6
Mental confusion or semi-stupor	5
Cyanosis	3
Signs suggestive of cardiac dysfunction	
Persisting tachycardia (120 or above)	8
Arrhythmia (transient fibrillation 1, extra systoles 7)	8
Bradycardia (below 65)	2
Apical systolic murmur	2
Friction rub precordial	2
Paradoxical pulse	1
Nausea and vomiting	1
Cardiac tamponade	5
(Recognized clinically 3)	
(Suspected but untreated 1)	
(Unsuspected 1)	

* This table is a compilation of the number of *times* that each sign or symptom was noted in proven cardiac cases. In a few instances the findings were noted on the records but their significance was not appreciated until after the cardiac lesions had been discovered at operation or at autopsy.

multiple wounds, hemorrhage, and large hemothorax or pressure pneumothorax. There remain cases in which peritoneal contamination can be ruled out and in which hemothorax and hemorrhage have been corrected by thoracentesis and transfusion. In these, there may be persisting dyspnea, cyanosis, or mental confusion which are out of proportion either to the visible thoracic damage or to the signs of continuing hemorrhage. In such instances a cardiac lesion may be assumed to be the basis for the continuing anoxia.

Direct evidence of cardiac dysfunction may be encountered. It is certain that more frequent cardiac examinations would have increased the number of

positive findings. Thus, three medical officers made all eight observations of arrhythmia. As with anoxia, other causes of tachycardia must be eliminated before it can be assumed that the continuing rapid pulse is of intrinsically cardiac origin. A soft systolic apical murmur is an exceptional finding.¹ The one example of paradoxical pulse was noted in a patient with severe myocardial contusion who died in the shock ward. Friction rubs were heard preoperatively in but two patients. In both, operation had been delayed and the rub became audible 24 hours after injury. Since a friction rub on splash was noted in eight additional cases postoperatively, it is evident that a certain time-interval is necessary for this sign to appear.

Persistent nausea with vomiting was seen during the preoperative period in one patient. Such a finding is rare in uncomplicated thoracic wounds and in the instance cited, it was possibly attributable to the cardiac wound.

TABLE II—Type of Cardiac Wound, 57 Cases

Anatomic Portion Involved	Lesion					Total
	Contusion	Pure Laceration	Laceration and Contusion	Perforated Chamber	Embolism to Heart	
Ventricle						
Left	7	7	5	7	0	26
Right	5	2	2	3	2	14
Both	3	0	2	0	0	5
Auricle						
Left	0	0	0	2	0	2
Right	1	1	0	7	0	9
Right auricle and right ventricle	0	0	1	0	0	1
Total lesions	16	10	10	19	2	57
Deaths						
Total	11	1	5	9	1	27
Due to heart (rate)	6 (37.5%)	1 (10%)	4 (40%)	8 (42.1%)	1 (50%)	20 (35.1%)

In comparison to the great frequency with which it is noted in civilian cardiac injuries, tamponade was an unusual finding in war wounds of the heart. The missiles were larger and, frequently, wide pericardial lacerations usually allowed ample drainage into the pleural cavity. Tamponade always must be kept in mind because of its lethal potentialities. The blood often comes from a cardiac chamber, but it may also come from a severed coronary branch, from a vessel in the pericardium, or from the myocardium itself. Death occurred twice due to unrecognized tamponade although in one patient, with a severe thoraco-abdominal wound, it was suspected. In this instance exploratory puncture was not successful because all the blood in the pericardium had become clotted. In the three cases where tamponade was recognized, the diagnosis was based on the findings of distended neck veins, muffled heart sounds, and a "water-bottle" shape of the cardiac shadow. Lowered

pulse pressures were not recorded in these three cases. Fluoroscopy could have been used in determining whether or not pulsation was decreased or absent. Hemopericardium of from 50 to 150 cc was noted in five additional cases at operation. In none had there been clinical evidence of increased intrapericardial pressure.

A precordial crunch or click synchronous with heartbeat and associated with mediastinal emphysema was heard occasionally. This sign was *not* indicative of cardiac trauma.

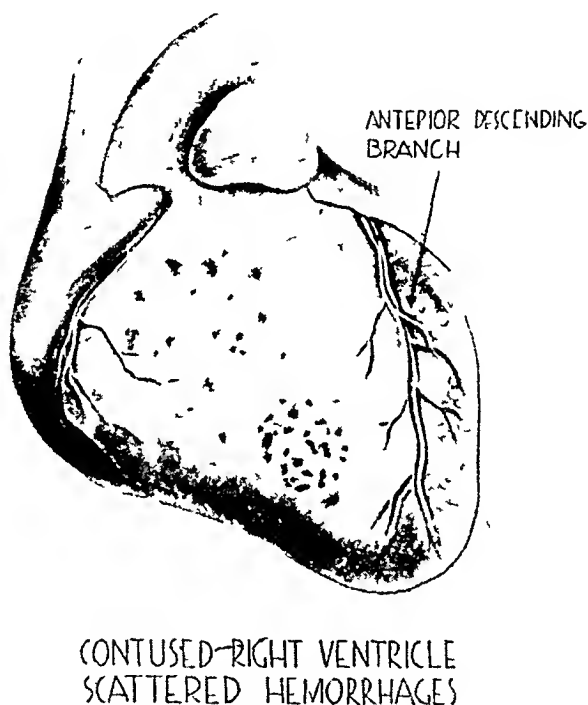


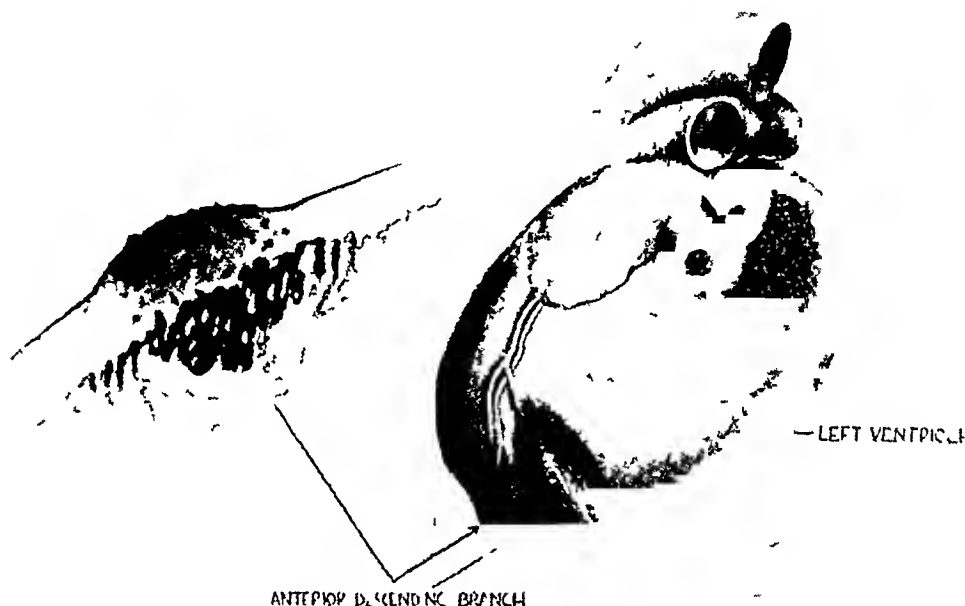
FIG 1—This patient was wounded by high velocity machine gun bullets and he suffered a long gutter-wound of the sternum with multiple fractures of the cartilages on the left. There were scattered patchy contusions of the right ventricle with an area of confluent intramuscular hemorrhage and softening near the apex. "Cardiac" death 35 hours after wounding.

PATHOLOGY

The cardiac lesions which were seen at surgery or autopsy have been classified as follows: Myocardial contusion, pure lacerated or incised-type wounds, laceration with myocardial contusion, penetrating and perforating wounds of the chambers, embolus to the heart (see Tables II and III). Cases in which foreign bodies were found in the myocardium or chambers were placed in the various pathologic categories depending upon the type of myocardial injury produced, irrespective of whether or not the foreign body was

still present. In general, the signs and symptoms exhibited, the indications for surgery, and the causes of death, differed in the various pathologic categories.

Insofar as operative therapy is concerned, contusive lesions of the myocardium are non-surgical. Pathologically they are apparently identical to the contusions resulting from blunt trauma to the chest and from "steering wheel" injuries which have been described by Beck² and Elkin.³ In most battle-incurred contusions, however, the pathogenesis is different in that the contusive force often is propagated by the passage of missiles of varying size and usually high velocity in the immediate vicinity of the heart. The wounding



CONTUSED LEFT VENTRICLE -- CROSS SECTION
SHOWING ENDOCARDIAL THROMBI.

FIG 2—This patient sustained an extensive tangential sucking wound of the left chest antero-laterally. Rib fragments, apparently acting as secondary missiles, caused a severe localized contusion of the left ventricle with superficial laceration of the epicardium and thrombosis of the epicardial veins. The pericardium was intact. Hemorrhage extended through the myocardium to the endocardium. Mural thrombi were present in the chamber of the ventricle. "Cardiac" death on the operating table, 17 hours after wounding.

power of a missile is believed to be more directly proportional to its velocity than to its size or shape.⁴ Thus, a high rate of energy is imparted to the tissues in the track of the missiles and particles of tissue thrown laterally pass their energy on, producing further damage. In at least two patients, extensive myocardial contusion resulted from fractured ribs or sternum acting as secondary missiles. Among the pericardial cases, two wounds were caused directly by rib fragments. Such a sequence was found particularly in tangential wounds. None of the contusions in this series was believed due to "blast," i.e., a positive pressure wave in the atmosphere.

In contusive lesions, the pathology consists of scattered or confluent petechial hemorrhages involving the myocardium over varying areas of one or two chambers (Fig 1) The hemorrhage may extend through to the endocardium With actual injury to the endocardium, or with subendocardial hemorrhage, adherent mural thrombi may develop These have been found in five cases at autopsy (Fig 2) When extensive lesions are scattered along the acute or obtuse margin of the heart, the hemorrhage may involve the myocardium of both ventricles and extend into the interventricular septum Superficial abrasions of the epicardium and engorgement or thrombosis of the sub-epicardial

TABLE III—Deaths in Cardiac Lesions

Lesion	Ventricle			Auricle		Right Auricle Right Ventricle	Total
	Left	Right	Both	Left	Right		
Contusion							
Total deaths	4	4	2	0	1	0	11
Death due to heart	3	2	1	0	0	0	6
Type of cardiac death	(c c \)	(c, \)	(\)				(6)
Pure laceration							
Total deaths	7	2			1		10
Due to heart	1						1
Type of cardiac death	(c)						(1)
Laceration and contusion							
Total deaths	2	1	2				5
Death due to heart	1	1	2				4
Type of cardiac death	(c)	(c)	(c c)				(4)
Perforated chamber							
Total deaths	2	1		1	5		9
Death due to heart	2	1		1	4		8
Type of cardiac death	(c h)	(t)		(c)	(h h h t)		(8)
Embolism to heart							
Total deaths		1					1
Death due to heart		1					1
Type of cardiac death		(c)					(1)

In Tables III VI VII and VIII all figures in parentheses represent deaths due to the heart itself Each symbol within the parentheses represents a single case of death due to the heart

- (c)=Death due directly to the cardiac lesion Usually sudden or rapid death
from infarction fatal arrhythmias or lethal myocardial damage 11 cases
(h)=Death due to exsanguination from the heart 4 cases
(t)=Death due directly to tamponade 2 cases
(\)=The heart lesion an essential contributory cause of death 3 cases

vessels are often found When a major artery is contused sufficiently, thrombosis is probable The myocardium may show gross evidence of degeneration or actual necrosis Microscopically, there is interstitial hemorrhage which varies in severity and extent The muscle fibers show fragmentation, loss of striation, or advanced necrosis Eosinophilia, leucocytic infiltration, and beginning phagocytic removal of necrotic muscle have been observed as early as 18 hours following injury

In the group of contusions there was a death rate of 37.5 per cent due to the cardiac lesion itself (Table III) Of the 16 cases of myocardial contusion, nine had an intact pericardium

The other types of myocardial damage listed above may be classified as "potentially surgical" lesions. In the laceration category are placed all cases with incised-type or cleanly lacerated wounds of the myocardium in which there was no gross evidence of myocardial contusion or necrosis. Two cases with foreign bodies in the myocardium are included here since the myocardial wound fitted this classification pathologically. The less serious nature of this type of wound is demonstrated by the single death due to the heart in ten cases of pure lacerated wounds.

When lacerated wounds are associated with extensive contusion, the lesion is a serious one. In this group the typical gross appearance is that of a myocardial laceration, the edges of which are elevated and discolored and show areas of hemorrhage. The edges may be friable so that attempted suture and approximation are fraught with difficulty. In this category there was a 40 per cent death rate due to the heart.

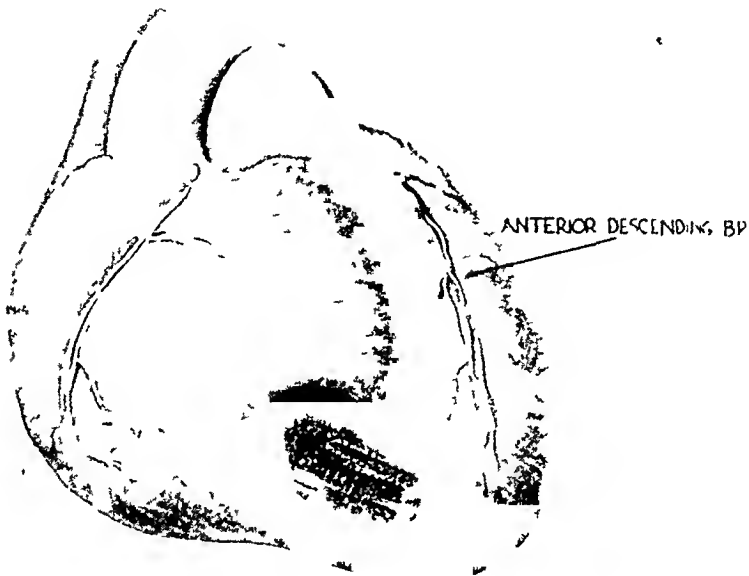
In wounds penetrating to the chambers of the heart, hemorrhage is the most frequent complication and the most important cause of death. The hemorrhage may be slight, exsanguinating, or cause tamponade. Frequently, penetrating or perforating wounds of the chambers do not result in exsanguination because the missile may pass through the myocardium at an angle so that the wound is partially closed. A small penetrating wound may become occluded by clot. The position of the right auricle offers some protection in wounds of this chamber since the lung may collapse against the auricle and temporarily control hemorrhage. As with other cardiac wounds there may be associated laceration and contusion of the myocardium which complicate surgery and repair. The death rate due to the heart among cases of wounds penetrating the chambers was 42 per cent.

There were six cases of perforating (through and through) wounds of the chambers in this series. Two occurred in the left ventricle and both survived following suture. One of these cases has been reported in detail elsewhere.⁵ In four cases of perforation of the auricles there were three deaths. No case of perforation of the interauricular or interventricular septum survived to reach a forward hospital.

Instances of foreign body embolism to and from the heart form a small but interesting group. There were four examples in this series. In two the missile came to rest in the right ventricle by way of the inferior vena cava. In one of these the situation was recognized and a .45 caliber bullet successfully removed.⁵

In the other case the shell fragment "disappeared" after having entered the body through the right flank. The initial thoracic roentgenogram revealed the questionable presence of a missile just above the left diaphragm near the midline. The films were repeated later using soft tissue penetration technique and the foreign body was not visualized. Over a period of nine days the patient had attacks characterized by decreased blood pressure, high fever, mental confusion, pallor, rapid pulse, and "shocky" appearance. Malaria was suspected and the patient appeared to improve temporarily on quinine ther-

apy In retrospect the attacks could well have been due to myocardial ischemia. Sudden death occurred ten days after wounding. At autopsy the right ventricle was found to be greatly dilated and the myocardium overlying the foreign body was hemorrhagic and necrotic (Fig 3). Early removal of the shell fragment from the chamber of the right ventricle probably would have been life-saving.



SHELL FRAGMENT EMBOLIC TO RIGHT VENTRICLE

FIG 3—Semi-schematic transparency of a shell fragment, 20x15x10 mm which became embolic to the right ventricle by way of the inferior vena cava. The overlying musculature was hemorrhagic and necrotic over an area 4 x 5 cm near the apex. The right ventricle was greatly dilated. Sudden death 10 days after wounding.

As an embolus from the heart, the foreign body may enter the pulmonary circulation, become retrograde in the systemic venous circulation, or enter the systemic arterial vessels. In one case in this series the missile entered the right auricle, dropped into the inferior vena cava, and eventually was recovered from the left common iliac vein.⁶ In the fourth case a bullet entered the left ventricle and came to rest in the right flank region, presumably in the right common iliac artery. The patient had no symptoms of arterial obstruction.

OPERATIVE TREATMENT

Ten of 16 lacerated wounds of the myocardium which were exposed at operation were not repaired (Table IV) There seemed to be no immediate ill effect resulting from lack of repair Further, of the cases of laceration seen at autopsy only, none of the deaths were believed to be due to lack of repair A repair was listed as complete if the edges of the laceration had been entirely approximated with sutures (Fig 4) Partial repair (two cases) was that in which complete approximation of the edges could not be obtained and pericardium was used to help bridge the defect (Fig 5) The pericardium was frequently employed as a secondary covering being either sutured over

TABLE IV—Incidence Repair Heart Lesions *

		Ventricle			Auricle		Right Auricle	Total
		Left	Right	Both	Left	Right	Right Ventricle	
10 Lesions seen autopsy only	Lac	1	1	2	0	0		4
	Perf	1	1		1	3		6
29 Lesions seen at operation	Lac	11	3	0	0	1	1	16
	Perf	6	2	0	1	4	0	13
		—	—	—	—	—	—	—
		19	7	2	2	8	1	39
Of 29 cases visualized at operation								
Complete repair of	Lac	1	2	0	0	0	1	4
	Perf	6	1	0	1	2	0	10
Partial repair of	Lac	2	0	0	0	0	0	2
	Perf	0	0	0	0	0	0	0
No repair	Lac	8	1	0	0	1	0	10
	Perf	0	1	0	0	0	0	1
Repair attempted and failed	Lac	0	0	0	0	0	0	0
	Perf	0	0	0	0	2	0	2

Laceration==Wounds with and without contusion

Perforation==Penetration or perforation of chambers

* 39 lesions exclusive of pure contusions and embolus to the heart

the closed wound or sutured to the lips of a poorly approximated wound The edges of the pericardium were imbricated in some cases to give additional strength When the pericardium was sutured over a myocardial wound it was first drained posteriorly Note was made in two cases of the use of free muscle grafts to aid in the control of bleeding

Of 13 wounds involving the cardiac chambers, complete closure was obtained successfully in ten One wound was not bleeding at the time of operation and was not sutured In two auricular wounds, closure could not be accomplished and the patients died of uncontrollable hemorrhage In both, attempts were made to plug the defect in the auricular wall with the finger

The foreign body was described as in the heart or pericardium in 21 cases The typical removal of a foreign body is shown in Figure 6

These figures show a low percentage of removal. The majority not removed were small fragments, 0.5 cm or less. In several, the condition of the patient did not warrant further search. The foreign bodies marked "probable" were not definitely located but from roentgen evidence and operative findings, their presence in the pericardial sac seemed likely. Of the eight foreign bodies found at autopsy, the missile was directly responsible for one death (embolus to the heart) and possibly for a second death. (See also Analysis of Deaths.)



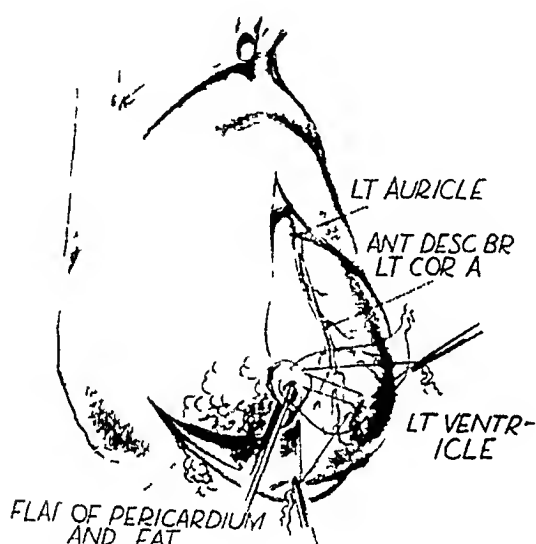
FIG 4—Incised-type lacerated wound of the right ventricle without gross myocardial contusion. In repair the sutures were passed through the muscle just at the bottom of the laceration and not through the endocardium. Recovery.

THE PERICARDIUM

There were 18 cases in which the pericardium alone was injured. In 14 the wounds were lacerated and in four, foreign bodies were embedded in the pericardium. Two of these were metallic and two were rib fragments. Of all the wounds in which the pericardium was opened it was sutured tightly in five cases, in the remainder the pericardium was drained into the pleural cavity. In two of the five cases (one, a pure pericardial injury and one a myocardial wound) there was massive troublesome pericardial effusion postoperatively. This was not noted in any of the cases which were drained.

POSTOPERATIVE FINDINGS

In the patients that lived, certain findings relative to the heart were recorded. Eight patients developed friction rubs approximately 24 hours postoperatively and some of these were audible up to three weeks. One patient had numerous extra systoles for three days following operation. Three patients suffered significant myocardial accidents during the postoperative period. One showed mild symptoms and signs of myocardial infarction 19 days following a self-inflicted stab wound. The second patient had had extra systoles preoperatively. He developed sudden precordial pain, circulatory collapse and transient auricular fibrillation 24 hours after operation (33 hours after injury).



Frequent extra systoles were present for 14 days thereafter. At operation there was a clean superficial laceration of the left ventricle at the apex and it was necessary to ligate a terminal radicle of the anterior descending branch which was continuing to bleed. The third patient had a repair of a wound which penetrated to the left ventricular chamber. Fifteen days following operation he was suddenly seized with severe precordial pain. Dyspnea, cyanosis, and pulmonary edema developed. Acute left ventricular failure was diagnosed. He was somewhat improved in four hours and was asymptomatic by the end of 48 hours.

One patient developed complete right-sided hemiplegia. At operation,

a 3 cm laceration of the left ventricle was discovered. A second patient with a lacerated wound of the left ventricle entered the shock ward with a cold, pulseless left foot which did not completely return to normal for 36 hours. One must consider the possibility that the complications in these two cases were due to emboli resulting from the detachment of mural thrombi in the left ventricle.

ANALYSIS OF DEATHS

There were 30 deaths in the entire series. Three were among the 18 cases of pericardial wounds. All of these occurred more than 48 hours following operation and none was due to the pericardial involvement. Twenty-seven deaths occurred among 57 patients with myocardial lesions, of these, 20 were

due directly to the heart. This is a "cardiac" death rate of 35 per cent. The remaining seven deaths were due to the severity of thoracic-abdominal or esophageal wounds, shock, bronchopneumonia, and anuria.

Tables VI and VII give a breakdown according to time and cause of death. Of the 11 "myocardial" deaths (c), four were in poor condition on admission and died either before or during operation. One was apparently in good condition and died suddenly during operation. Six died postoperatively. Three of these died suddenly and without warning, three died shortly after symptoms of myocardial infarction had developed. In the three cases where the heart was considered an essential contributory cause of death (x), the cardiac lesion was extensive in all. Other wounds were also severe and it cannot be said, therefore, that the heart was the sole cause of death.

In Table VIII the cardiac deaths have been analyzed with reference to the possible surgical correction of the cardiac lesion. This includes the removal of foreign bodies and the suture of lacerations or perforations. As expected, none of the contusions could have been helped by surgery. In the single patient with pure myocardial laceration who died immediately following

TABLE V—*Fate of Foreign Bodies*

	Pericardium	Pericardial Sac	Myocardium	Completely in Chamber
Number of cases	4	3 (2 probable)	10	4 (2 embolic)
Removed at operation	4	1	3	1 (embolic)
Not removed	0	2 (both probable)	7	3
Found at autopsy			(5)	(3)

surgery, there is no evidence that suture would have been beneficial. In this case there was an early pericarditis from contamination by stomach contents, but its significance cannot be evaluated. Of five cases of myocardial laceration and contusion (including one repaired perforation), the damage appeared to have been lethal in four and no conceivable further repair would have changed the fatal outcome. In three of these, for example, the anterior descending branch of the left coronary artery had suffered a traumatic thrombosis for at least half its length while the fourth patient again had an early pericarditis from contamination with stomach contents. The fifth case, in the "possibly benefited" column, concerns a retained foreign body. In this instance the patient died suddenly four hours following debridement of his thoracic wound. At autopsy a shell fragment, 15x10x10 mm, was found lying in contact with the sternum. It was in a shallow, contused, lacerated wound of the right ventricle at the base of the pulmonary conus. It is possible that the continued presence of the foreign body was instrumental in propagating fatal ectopic stimuli. Removal might well have been beneficial. The pericardium contained 150 cc of liquid blood, but it was not tense, and the mode of death did not seem to be that of pressure from tamponade.

The fatal embolus to the right ventricle has been described previously. Its early removal probably would have been life-saving.

As might be expected, the largest group which could have benefited from surgery was that in which penetration of the chamber had occurred. Successful repair of the defect in the six cases listed would probably have been life-saving. Of the four dying from exsanguination (h), one died in the shock ward and two died on the table. The fourth case had an unrecognized perforating wound of the right auricle. The patient's original hemorrhage seemed to have ceased at the time of débridement of the thoracic wall, but there was rapid exsanguination before further surgery could be performed 36 hours after

TABLE VI—*Total Deaths* (Among 57 cases with myocardial wounds)

Time of Death	Pure Thoracic	Thoraco abdominal	Total
Preoperative			
Total deaths	1	1	2
Due to heart	(h)	(c)	(2)
During or immed postoperative			
Total deaths	5	5	10
Due to heart	(c, c, h, t)	(c, c, h, t)	(8)
1-5 hours postop			
Total deaths	1	3	4
Due to heart	(c)	(c, v)	(3)
6-12 hours postop			
Total deaths	0	2	2
Due to heart	(0)	(0)	(0)
13-24 hours postop			
Total deaths	5	1	6
Due to heart	(c, h, v)	(c)	(4)
25-48 hours postop			
Total deaths	0	1	1
Due to heart	(0)	(v)	(1)
Over 48 hours postop			
Total deaths	1	1	2
Due to heart	(c)	(c)	2
Deaths (total)	13	14	27
Due to heart	10	10	20

injury. One of the two fatal cases of tamponade (t), was entirely unsuspected. The second case was recognized too late, although it is probable that the patient eventually would have died from his severe thoraco-abdominal wounds. The mode of death in the seventh case (c), is difficult to explain. Death was sudden and, therefore, probably due to myocardial dysfunction. The patient had a through and through wound of the left auricle. There was approximately 100 cc of blood in the pericardium although no evidence of tamponade. One can only speculate as to whether or not repair of the defects would have been successful in preventing the immediate death. It is probable, however, that the patient could not have long survived without repair.

THE TIME AND PLACE FOR CARDIAC SURGERY IN WAR WOUNDS

It is particularly difficult to decide these matters when confronted with war wounds of the heart. When a cardiac wound is suspected, a judgment should be made if possible as to the type of pathology present and as to the presence or absence of a foreign body in the heart or pericardium. Three questions must be answered: (1) Can the cardiac lesion itself be corrected by surgery? (2) If so, should this surgery be performed in a forward hospital or at the base? (3) What is the effect of the cardiac status on the patient's ability to withstand needed surgery for other wounds? By contrast to civilian cardiac wounds, the heart in war casualties is often but one of several organs involved and both the diagnosis and the decision as to time of operation are complicated by the presence of multiple injuries.

The problem may be partially simplified by considering each type of myocardial injury more or less separately. When a contusion is suspected, decision must be made as to when to operate on concomitant wounds. As

TABLE VII—*Time of Occurrence of Deaths Due to Heart, Segregated by "Lesion"*
Number of deaths occurring

Cardiac Lesion	Preop	During or Immed		1-5		6-12		13-24		25-48		Over 48 hr
		p	o	hr	p o	hr	p o	hr	p o	hr	p o	
Contusion	(6)	(c)		(c)	(x)			(c x)		(x)		
Pure lac	(1)			(c)								
Lac and contus	(4)			(c)	(c c)			(c)				
Perf chamber	(8)	(h)		(c h h t, t)				(h)				(c)
Embolus to ht	(1)											(c)
Totals	(20)	(2)		(8)	(3)			(4)		(1)		(2)

stated above, the contusion, *per se*, is not a "surgical" lesion. The fact that six of 11 deaths in the contusion group were due to the heart shows that these patients were not good operative risks. The diagnosis of a cardiac contusion should not be extremely difficult since it has been noted in the present series that the majority of signs and symptoms indicative of anoxia and of cardiac dysfunction (persistent dyspnea, tachycardia, arrhythmia, etc.) were found in patients who had significant contusions of the myocardium.

In myocardial contusion, the clinical and pathologic picture is thus similar to that in myocardial infarction following coronary thrombosis, and we have felt that these patients might well be handled as if they had an acute coronary occlusion. If this analogy be carried further, then the first 24 to 48 hours is an extremely critical time for surgical intervention since the danger of cardiac standstill and lethal arrhythmias may be enhanced by anesthesia or operative manipulations. In many cases, however, attention must be given to other serious concomitant trauma, especially thoracic-abdominal wounds where undue delay in surgery usually is disastrous. Under these circumstances it is

best to prepare the patient as thoroughly as possible consistent with the major surgical lesion. The mortality rate in such cases inevitably will be high. There remains a group of cases with purely thoracic wounds in which early surgery (within six to 12 hours) is not mandatory and wounds in which delay, because of a cardiac contusion, may be practicable.

Viewed from this standpoint the cases of contusion were reviewed. There were three, all with a fatal outcome, in which it was felt that further delay in surgery probably would have been beneficial. Two had thoracic wounds and one had a high thoracico-abdominal wound in which it was obvious that only the liver was involved. The time lag between wounding and surgery was 17, 11, and 5 hours respectively. In each instance, signs of cardiac dysfunction were prominent. During resuscitation the patients remained in poor general condition in spite of an increase of the blood pressure to 95 or above. Rapid pulse, dyspnea, and semi-stupor were out of proportion to the obvious intra-thoracic damage. In each instance death occurred during, or shortly following

TABLE VIII—*Cardiac Fatalities (20) With Reference to Surgical Correction*

Cardiac Lesion No. of Deaths		Would Have Been Benefited by Surgery	Possibly Would Have Been Benefited	Could Not Have Benefited From Surgery
Contusion	6	0		6
Pure lac	1	0		1
Lac and cont	5*	0	1 (c)	4
Perf chamber	7	6 (h h h h, t, t)	1 (c)	
Embolus to heart	1	1 (c)		
	—	—	—	—
	(20)	(7)	(2)	(11)

* This includes one case of perforation of chamber which was successfully repaired but died a "myocardial death" because of extensive laceration and contusion.

surgery. We have also studied the record of a fourth case (not included in this series) in which there was a single thoracic wound, a six hour lag, and sudden death on the operating table. At autopsy this patient showed extensive contusion of the right ventricle and thrombosis of the anterior descending branch of the left coronary artery. While any of these four patients might well have died without operation, surgery could not be deemed mandatory at the time it was performed. The added burden of an anesthetic and an operative procedure cannot be ignored as probably precipitating the fatal outcome.

In contrast to the relatively early surgery in these four patients, two other cases may be cited in which initial surgery was considerably delayed (three and five days after wounding). Both were in shock on admission to the hospital and cardiac contusions were diagnosed. In one, a friction rub was audible 24 hours after wounding and the pulse remained over 120 beats per minute for 48 hours. The second patient had intermittent periods of cardiac arrhythmia for four days, associated with excessive bronchial secretions and jaundice. Both patients recovered from surgery. It was our strong feeling that operation

performed in either case at 12 hours or less might have ended disastrously. In summary, when a cardiac contusion has been diagnosed and indications for early operation such as continuing hemorrhage or thoracico-abdominal involvement are not present, surgery probably should be postponed for a minimum of 48 hours, to give every opportunity for myocardial irritability to regress.

The feasibility of early thoracotomy for the express purpose of suturing cardiac lacerations cannot be settled. With cleanly-lacerated or incised wounds there are few if any symptoms of cardiac dysfunction and damage to the heart can only be suspected from the course or location of the missile or from a possible tamponade. Of the lacerations exposed surgically in this series of cases only 38 per cent were repaired and there appeared to be no immediate disability from lack of repair. Certainly some lacerations should be untouched since attempts at suture may lead to further difficulties. Such wounds include the superficial, non-bleeding lacerations of one or two mm in depth, particularly if they involve the musculature of the left ventricle, round or oval lacerations especially in the region of the apex, and lacerations near a major coronary vessel, the repair of which might cause thrombosis. Shallow ovoid lacerations frequently remain after a superficial foreign body is removed (Fig 6) and repair may not be necessary. When the heart is exposed for any reason, however, the suture of certain lacerations is better accomplished at a forward hospital. It is probable that no efficient repair can be performed in a base section hospital ten or more days after injury. Retraction of edges of the myocardial defect and induration from fibroblastic tissue proliferation combine to defeat a good approximation.

Penetrations or perforations of the cardiac chambers are usually manifest by continuing hemorrhage and early surgery is mandatory. If foreign bodies are found or if it is suspected that they are in the chambers, an attempt should be made to remove them at the same time, but it should be remembered that the main indication for operation at this time is the control of hemorrhage. Long-continued search or blind manipulations within the chambers are not justified. If the missile is not found almost immediately, the defect should be sutured and further consideration given to removal of the intracardiac fragment at a base hospital.

If the bleeding causes tamponade rather than exsanguinating hemorrhage, the treatment may be more individualized. Should the tamponade develop rapidly it is probably better to operate at once, particularly if it is known that the missile causing the injury is large. If, however, the tamponade develops slowly, one or two aspirations may suffice as has been suggested by Stieder⁷ and Blalock,⁸ and major surgery may not be necessary.

When foreign bodies are suspected of being in the pericardium or myocardium their removal should be postponed until the patient can be evacuated to a base section center unless hemorrhage persists or symptoms of cardiac dysfunction recur. Two other factors enter into the considered opinion for recommending a delay in the removal of cardiac foreign bodies. In the present series, nine of the 13 missiles believed to be in the pericardial sac or myo-

cardium were not removed. Furthermore, Harken⁹ in a base section thoracic center operated on 56 patients for the removal of missiles from the heart or pericardium. None of these patients died.

Metallic foreign bodies may come to rest in a cardiac chamber either by traversing the myocardium directly or by embolism through the pulmonary or systemic venous system. Cases of foreign body embolism to the heart are now

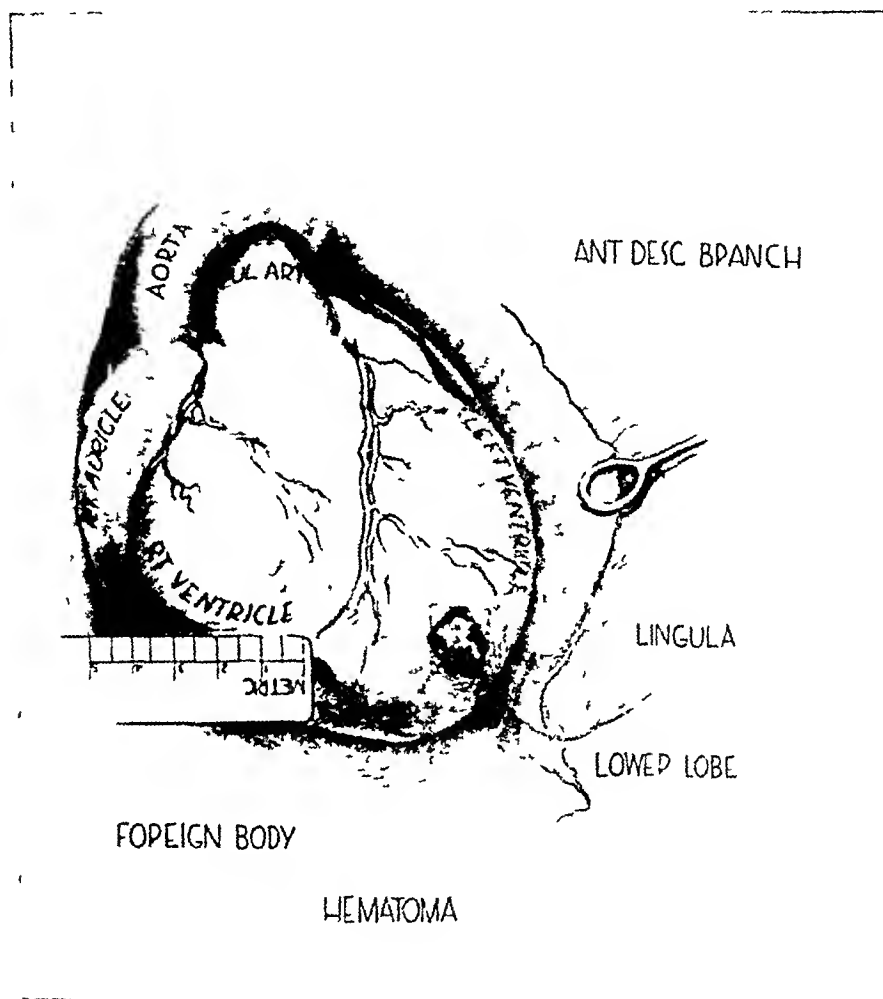


FIG 6—(Reprinted with permission from *J Thor Surg*, 15, 1, 1946) A case in which the shell fragment was removed 40 hours after injury. Cloth was attached to the foreign body. The missile was known to be in the myocardium and was relatively large (20 x 13 x 9 mm). The myocardial defect was oval and the muscle at the edges was necrotic and soft. No repair of the muscle was attempted but the pericardium was sutured over the defect. Recovery. (Illustration courtesy of L. A. Brewer²⁰)

being recognized more frequently. In the past, their removal has been the subject of much discussion.^{1, 10, 11} While some intracavitary missiles have remained asymptomatic, others have caused death from primary pulmonary embolism,^{12, 13} secondary pulmonary embolism,¹⁴ focal infection,¹⁵ and direct myocardial damage.¹⁶ In one of Harken's¹⁷ cardiectomies myocardial thinning was seen in the right ventricle overlying an embolic shell fragment.

In 1938 Decker reviewed 20 personal and collected cases of foreign bodies which were free in the cardiac cavities. Four of these were subjected to cardiectomy with one death (25 per cent), 16 were not operated upon and there were nine deaths (56 per cent). It is apparent that improved surgical technic and better anesthesia have combined to reduce greatly the risk of cardiectomy. Witness Harken's recent series of 13 cases in which intracavitary missiles were removed with no mortality.

Our present attitude regarding "potentially surgical" war wounds of the heart may be summarized as follows. The only absolute indication for early cardiac surgery in forward hospitals is continuing severe hemorrhage or immediate cardiac tamponade. When the heart is normal in size and there are no disturbances of physiology, mere suspicion of a cardiac wound is not, in itself, sufficient indication for early thoracotomy. All patients who remain asymptomatic during the early period after wounding should be evacuated without specific cardiac surgery for final study and evaluation in a specialty hospital. If the patient is admitted to a forward hospital with signs of cardiac dysfunction (disproportionate dyspnea, arrhythmias, etc.) it is probable that myocardial contusion is present. This finding demands that all surgery be postponed for at least 48 hours whenever possible. When *delayed* or recurring episodes of myocardial irritation, bleeding or infection occur, corrective surgery should be undertaken in forward hospitals for the removal of foreign bodies and the repair of lacerations.

Nearly all intracavitary missiles should be subjected to delayed removal at a base section center. On the other hand, recognition that the foreign body in the chamber is causing cardiac disability or is the source of secondary emboli, constitutes an indication for early removal in a forward hospital.

COMMENT ON EXPOSURE AND SURGICAL TECHNIQS

When a "surgical" cardiac wound is diagnosed, adequate exposure through an elective approach is mandatory. In the presence of exsanguinating hemorrhage, for example, the tragedy of inadequate exposure has been experienced. For most purposes an anterior approach is greatly preferable and an intercostal incision always should be employed unless the corresponding rib is badly fractured. The third or fourth intercostal space offers the best exposure for the auricles and the fifth or sixth for the ventricles. In general, more of the right ventricle can be exposed through a *left-sided* incision than through a right-sided thoracotomy.

The incision should be carried to the sternum and the internal mammary vessels ligated and divided. When necessary, increase in vertical exposure may be obtained by division of one or more cartilages. Further horizontal exposure is facilitated by transverse section of the sternum at the level of the intercostal incision.⁹ The approach should be transpleural in all instances. We believe strongly that no time should be wasted in attempting an extrapleural operation. Such a procedure takes longer, exploration is more difficult and the exposure is not as satisfactory particularly for posterior wounds. In

addition, the usual hemothorax makes extrapleural exposures impractical. While it has not been employed by us, mention should be made of median extrapleural sternotomy of the Duval Barast type,¹ for cardiotomy on the right heart. Both auricles and ventricles are exposed simultaneously and the possibilities of missile migration from one chamber to another may thereby be lessened.

Ten cc of 5 per cent procaine usually have been injected into the pericardial sac for several minutes before exposing the heart. This materially cuts down the incidence of ectopic beats while the heart is being handled. Several

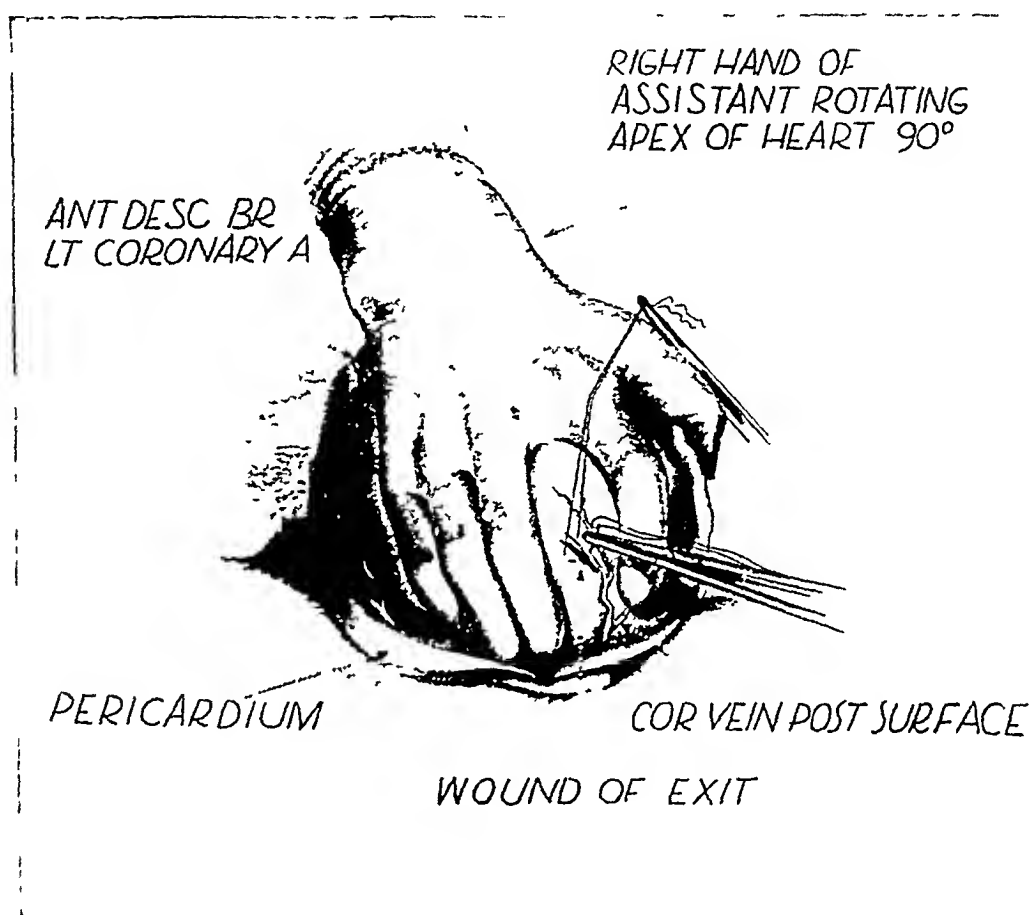


FIG 7—(Reprinted with permission from *Surgery*, 20: 373, 1946.) Forward rotation of the apex of the heart by the hand of the assistant surgeon. The diaphragmatic surface of the heart can thus be well visualized. By spreading the fingers any portion of this surface can be readily sutured.⁵

maneuvers have been employed in manipulating the heart. For anterior lesions, the "palming" method,¹ or the Sauerbruch grip has advantages. By the former means the third, fourth and fifth fingers are passed behind the heart, the index finger is passed in front, and the thumb is free to apply hemostasis or lateral pressure in stabilizing a missile. In exposing the diaphragmatic surface, some surgeons prefer the apical suture. The writer, however, has felt that the hand of the assistant makes a much better retractor (Fig 7). The apex of the heart can thus be rotated nearly 90° forward and the cardiac movements are con-

siderably dampened. By spreading the fingers a slotted type of retractor can be simulated which will expose any portion of the wall.⁵

We owe much of our knowledge of suturing technics to the well-known writings of Beck, Elkin, Bigger,¹⁸ and others. The general principles which they have promulgated form the background for most cardiac repair. Our chief concern here is in the emphasis on certain technics which are particularly valuable in dealing with large wounds. Suture material should be of braided 00 or 000 silk, preferably oiled or waxed. A small-eyed or atraumatic

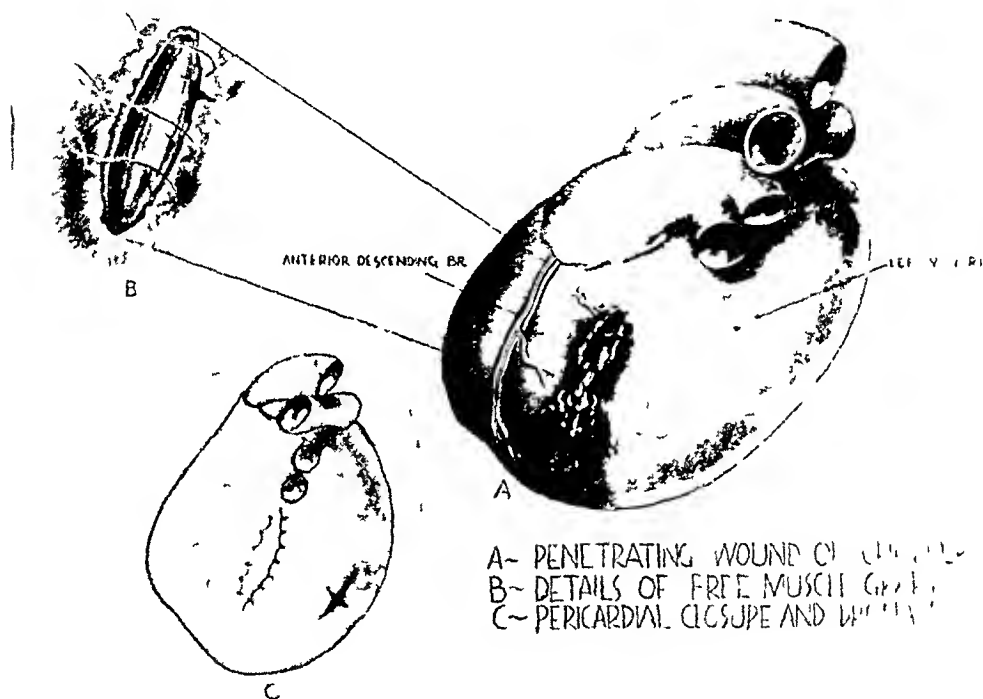
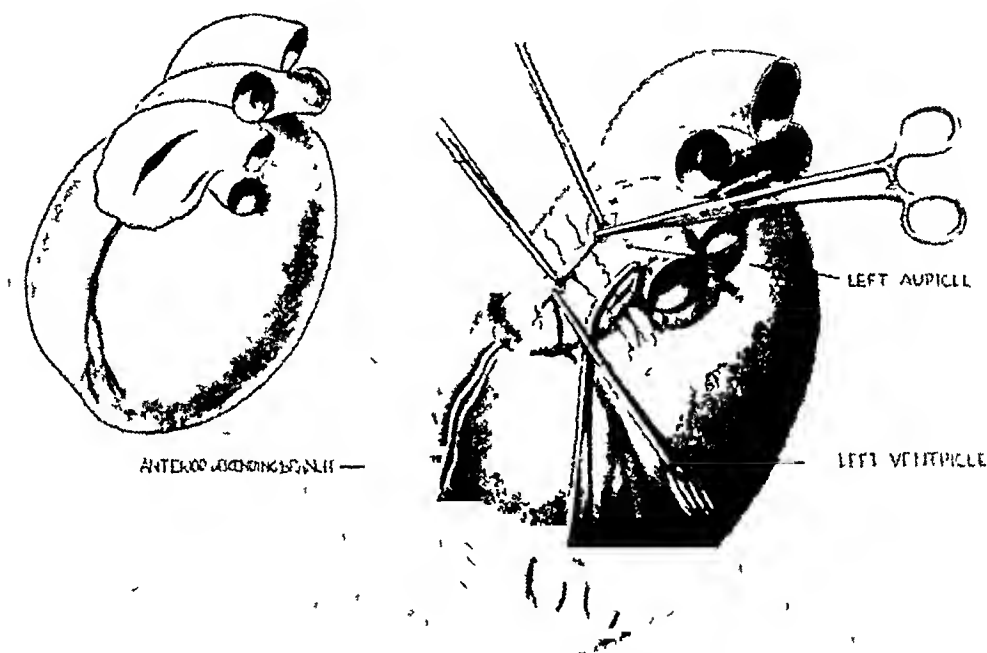


FIG 8—Ideal repair of a penetrating wound of the ventricular chamber with laceration, contusion, and softening of the muscle. The repair makes use of a free graft of voluntary muscle and imbrication of the pericardial edges over the myocardial defect. Note the posterior drainage of the pericardium.

needle should be used. Interrupted sutures always should be employed and should be placed close to the edge of the wound. They should be tied without undue tension, and during systole if possible. Pressure necrosis of the wound edges, particularly in wounds involving the chambers, may lead to secondary fatal hemorrhage. The sutures should not be passed through the endocardium as this increases the possibility of thrombus formation (Fig 4). In the repair of auricular wounds, however, this may be impossible to avoid. In general, lacerations of the right ventricle are easier to repair than those of the left

and since the wall of the right ventricle is thinner, it should be repaired more often. The justification for repair lies in the fact that the scar from a repaired laceration is stronger and the wall is thicker than if no repair is performed. Complete suture, or repair of some type is necessary if the bottom of the laceration feels thin or if there is any bulging. Without adequate suture in cases of this kind, later aneurysm of the myocardium may result and instances have been reported by Loison.¹⁰

Some lacerations because of loss of substance, or surrounding contusion and necrosis are difficult if not impossible to suture completely. Considerable



PERFORATING WOUNDS OF THE AURICLE

- 1 MODIFIED AFTER BECK
- 2 MODIFIED AFTER ELKIN

FIG 9—The closure of large auricular wounds 1 Modified after Beck (see text), 2 Modified after Elkin (see text)

ingenuity must be exercised, particularly if a chamber has been opened. Free muscle grafts are useful in this connection and should be employed more frequently. They can be laid in the defect and held in place by fine sutures. This not only helps to fill the defect but is instrumental in stopping hemorrhage or myocardial ooze (Fig 8). As a further reinforcing mechanism, the pericardium always should be sutured over the area of repair (after first providing drainage more posteriorly into the pleural cavity through a cruciate incision). The edges of the pericardium may be used and, when necessary, sutures may be taken into the epicardium or myocardium at the edge of the defect (Fig 5). The pericardium combines very nicely with a free muscle graft in giving a solid repair.

Wounds penetrating the chambers of the heart should be sutured even though not bleeding when first exposed. Later loosening of clot may lead to secondary hemorrhage if the wound has not been repaired. Large wounds of the auricles deserve special mention. Even a 3 cm wound of the auricle may not lead to immediate exsanguination. The lung may collapse against the auricle or a clot may form, each preventing fatal hemorrhage. The usual maneuver of occluding the defect with a finger, as employed in penetrating wounds of the ventricles, cannot be used in auricular wounds because of the thinness of the wall. If sutures cannot be placed at once, each edge of the auricular wall should be grasped with one or two fine hemostats. These may then be held in approximation or ligated temporarily until sutures can be properly placed (Fig 9). If the wound is at the edge of the auricle it can be completely occluded with a rubber-shod forceps while the wound is being sutured (Fig 9). Perforating (through and through) wounds of the chambers may be repaired successfully if both wounds can be exposed. No means has yet been discovered of repairing a wound of the posteromesial (or medias-tinal) surface of the right auricle. Two patients with this type of wound died from exsanguination but in both the hemorrhage came from the "free" wound. If the latter could have been repaired it is possible that the medias-tinal perforation would have sealed off.

When branches of the coronary arteries are bleeding careful ligature or suture of the individual branch is necessary. If fine metal clips are available they may be used as Beck has suggested.

Only certain aspects of closure need comment. We have used interrupted silk throughout. The pericardium should be drained posteriorly into the pleural cavity by means of a cruciate incision. If the sternum has been transected it should be wired firmly. In the presence of extensive intrathoracic injury we have employed intercostal water seal drainage of the pleural cavity.

SUMMARY

- 1 Seventy-five cases of war wounds of the heart and pericardium were given initial care by surgeons of the Second Auxiliary Surgical Group. This series comprised three and three-tenths per cent of all intrathoracic wounds operated on by members of the unit.

- 2 The cases have been reviewed with regard to diagnosis, pathology, operative treatment and postoperative course.

- 3 The causes of death have been analyzed with respect to the cardiac lesion and the probable influence of surgical intervention.

- 4 Based on observations of the participating surgeons and from personal experience both in forward and rear echelon hospitals, deductions have been made as to the advisability of early or delayed surgery in certain types of cases.

- 5 Comment has been made on operative approach and technic, emphasizing particularly the problems encountered in large wounds of the heart and in the phenomena of missile embolism.

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FRACTURES OF THE ACETABULUM

The Nature of the Traumatic Lesions, Treatment,
And Two-Year End-Results

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THIS IS THE SECOND OF A SERIES of three papers concerned with the analysis of 58 injuries of the hip joint which occurred in jeep accidents in World War II in the European Theatre of Operations. A previous paper has been concerned with dislocations of the hip joint⁵⁰. The present paper deals with fractures of the acetabulum without dislocation. A following paper will deal with fracture-dislocations. The mechanism of injury in each group of cases, as determined from the case history and by the circumstantial evidence from associated injuries in the ipsilateral extremity, was the same with few exceptions. The fracture of the acetabulum was a first-stage or incomplete "dashboard type" fracture-dislocation. In all of these injuries the fractures create incongruity of the joint surfaces, which is the first consideration in treatment. Damage to vascular structures of the joint capsule are assumed to occur only in dislocations and fracture-dislocations. The development of late complications, including the role of mechanical and vascular factors, are to be discussed by means of a comparative analysis of a two-year follow-up study of all types of cases in the final paper⁵¹.

The 16 cases of fractures of the acetabulum (Table I) to be presented in this communication fall into the following classifications:

Fracture of the rim of the acetabulum, five cases (three of the superior and two of the posterior rim)

Central fracture, eight cases (seven fractures of the body of the pubis and inner table of the pelvis, one fracture of the anterior rim and superior ramus of the pubis with intrapelvic protrusion of the head of the femur)

Comminuted or bursting fractures disorganizing the entire joint cavity, three cases

This division of cases fits in with many of the well-known textbook classifications⁶. It differs from the purely morphologic classifications in that it is not entirely theoretical, but based upon the morbid and roentgenologic anatomy of the region, upon present knowledge of the localization of function of various parts of the acetabulum, and upon the problems of treatment. It will be shown here and later⁵¹ that fractures which destroy a significant part of the superior and posterior rims of the acetabulum require open operation. Fractures limited to the anterior portion of the articular surfaces require only conservative treatment by means of traction. More extensive fractures which destroy the entire joint surface do not respond well to any form of treatment.

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FRACTURE OF THE ACETABULUM

TABLE I.—*Fractures of the Acetabulum in Military Personnel*

Case No	Age	Other Injuries of Ipsilateral Extremity	X-ray	Treatment	Weight-bearing (months)	Complications	Two-year Follow-up
16	21	Lacerated wound thigh, leg, knee	Undisplaced fracture superior rim	Traction 8 weeks	3	None	Normal hip, slight pain
17	20		Slightly displaced fracture superior rim	Traction 8 weeks	4	None	Pain and difficulty standing long periods
18	32	Hemarthrosis Lacerated wound knee	Displaced fracture superior rim	Open reduction, internal fixation	5	None	Normal hip occasionally mild joint pains
19	29	Pott's fracture	Widely displaced fracture posterior and inferior rims	Traction 8 weeks	4	Treatment neglected in enemy hospital for 2 months	Snapping hip, severe pain, slight limitation of motion
20	20	Fracture patella	Widely displaced fracture posterior and inferior rims	Fracture unreduced Traction 8 weeks	Not known	Not known	No follow-up
21	35		Undisplaced central fracture	Fracture unreduced Traction 6 weeks	6	None	Normal joint
22	24		Undisplaced central fracture	Bed rest 3 weeks	3	None	Normal motion of joint, slight pain and clicking
23	26	Severe contusion knee	Undisplaced central fracture	Traction 8 weeks	Not known	Not known	No follow-up
24	21	Lacerated wound knee	Undisplaced central fracture	Traction 8 weeks	3	None	Normal motion
25	42		Displaced central fracture	Traction 8 weeks	5	None	Slight pain Unable to lift heavy objects
26	22	Fracture patella	Displaced central fracture	Traction 8 weeks	6	None	Normal hip
27	29		Displaced central fracture	Traction 8 weeks	Not known	None	Normal motion, joint pains, difficulty standing long periods
28	39		Central fracture, body and descending ramus of pubis, infra-pubic protrusion of head	Lateral and longitudinal traction 8 weeks	4	None	No follow-up
29	29	Fracture midshaft femur	Comminuted fracture, displacement of all parts and superior and posterior rims	Traction 8 weeks	9	Injury kidney, persistent hematuria	Severe pain, ankylosis
30	25	Compound fracture upper third femur	Comminuted fracture, displacement of all parts and superior and posterior rims	Traction 12 weeks	18	Injury kidney, persistent hematuria	Severe pain, ankylosis
31	32		Comminuted fracture, displacement of all parts and superior and posterior rims, multiple fractures pelvic ring bilaterally	Traction 12 weeks	4	Laceration posterior urethra Suprapubic cystostomy Crushing injury and extirpation of the testicle	Severe pain, ankylosis

and usually result in great disability, frequently with associated ankylosis and degenerative arthritis

THE TRAUMATIC LESION

For intelligent evaluation and treatment of fractures of the acetabulum, certain important anatomic considerations must be clearly understood. The weight-bearing surface of the acetabulum consists of a lunate or horse-shoe-shaped platform of bone covered with articular cartilage. The anterior portion of the horseshoe, which is formed from the body of the pubis, is approximately half as wide as the superior portion. The anterior rim may be excised, as in arthroplastic operations, without seriously altering the function of the joint, but the posterior rim is necessary for stability. The superior shelving portion, which is the thickest portion of the innominate bone, is vital for the weight-bearing function of the acetabulum.

Fractures of the posterior rim of the acetabulum of various magnitudes, and involving various portions of its lunate articular surfaces, are not uncommon, and have frequently been observed and repaired. Fractures of the superior rim are extremely uncommon, presumably because of the volume of the bone and the adaptation of the stress lines of the trabeculae in this region to the burden of the weight of almost the entire torso⁵⁴. In one case of superior rim fracture in this series (case 18), at open operation the fragment contained 0.5 cm of the width of the articular cartilage, and the entire iliofemoral ligament was attached to the outer cortex of the rim of the fragment.

Fractures of the central portion of the acetabulum in this series showed an infinite number of patterns and various degrees of displacement. The variety associated with intrapelvic protrusion of the head of the femur has received the attention of many writers since 1788 when the lesion was described by Callisen and later provocatively termed "central dislocation" by Kronl  m in 1882.¹⁰ By 1928, with the new impetus from roentgen-ray methods of diagnosis, there were 138 cases of these rare injuries reported in the literature. Although many more cases have been reported since then, there are still great gaps in our knowledge of the traumatic lesion due to the inadequacy of routine roentgen-ray examinations, the lack of necropsy studies, and the infrequency with which the fracture has been seen at open operation.³⁶ Additional case reports continue to be important for information in proper selection of the cases for different types of treatment, and for data on the end-results. Most of the cases in the literature, like the cases reported in this series, were only partial protrusion and not the highly comminuted bursting type of fracture which is almost irreparable. A few of the cases illustrated in the literature are fractures of the body of the ischium and the triradiate seam of the acetabulum associated with a second fracture of the superior ramus of the ischium, but not much intra-pelvic protrusion was possible under these conditions.⁵⁵ In the majority of cases, when the head protrudes into the pelvis, there is a fracture of the anterior rim and the body of the pubis associated with a second fracture of the superior ramus of the pubis upon which the displacement of

the inner table of the pelvis hinges. The head of the femur escapes into the fracture site, which is the anterior portion of the acetabulum, and the vital superior and posterior lunate cartilages escape relatively unharmed. Usually the head is easy to draw out of the fracture site and replace in normal apposition to the horse-shoe-shaped cartilage and it can be held there by traction for



FIG 1-A —Roentgenogram of a fracture of the posterior rim of the acetabulum on the day of the injury as seen in the anteroposterior view. The displacement of the fracture was not considered significant by this examination (Case 19)

eight weeks or until healing occurs. The inner table of the pelvis remains displaced, but the anterior portion of the joint and the fracture site fill in with callus and are repaired by formation of new bone and fibrocartilage.

FRACTURES OF THE RIM OF THE ACETABULUM

The three cases of fracture of the superior rim and the two cases of fracture of the posterior rim of the acetabulum in this series were diagnosed by

emergency roentgenograms taken in field and evacuation hospitals. The patients were immobilized in hip spicas in 30° abduction, 20° flexion and neutral rotation and were transported without further treatment.

Conservative Treatment The degree of displacement and the size of the rim fragment determined the type of treatment for each case. Re-examination with more elaborate roentgen-ray equipment in fixed general hospitals in the communication zone, including posterior-oblique views, revealed undisplaced



FIG 1-B—Roentgenogram of the same case as illustrated in Figure 1-A, six weeks after the injury as seen in the posterior oblique view. This view demonstrates the displacement of the fracture. When the hip was examined in flexion in this case, little more than half of the original lunate cartilage of the acetabulum articulated with the head of the femur, but the joint was stable.

or very slightly displaced fractures in two cases, and displaced fractures in three cases. In one case the displacement was not appreciated until six weeks after the injury because of the failure to examine the fracture in the important posterior-oblique views (Case 19, Fig 1). In another displaced fracture (Case No 20) operative treatment was contraindicated because of severe

FRACTURES OF THE ACETABULUM

chest and head injuries. All of these cases were treated conservatively in traction-suspension for periods varying from three to eight weeks, depending upon the extent of the lesion, except one fracture of the superior rim (Case No 18) which is reported in detail below.

Surgical Treatment Because of the involvement of a vital portion of the acetabulum, Case 18 was treated immediately by open reduction and internal fixation. The hip joint was exposed by the anterior iliofemoral approach, exposing the joint capsule in the sulcus between the sartorius, the tensor fascia

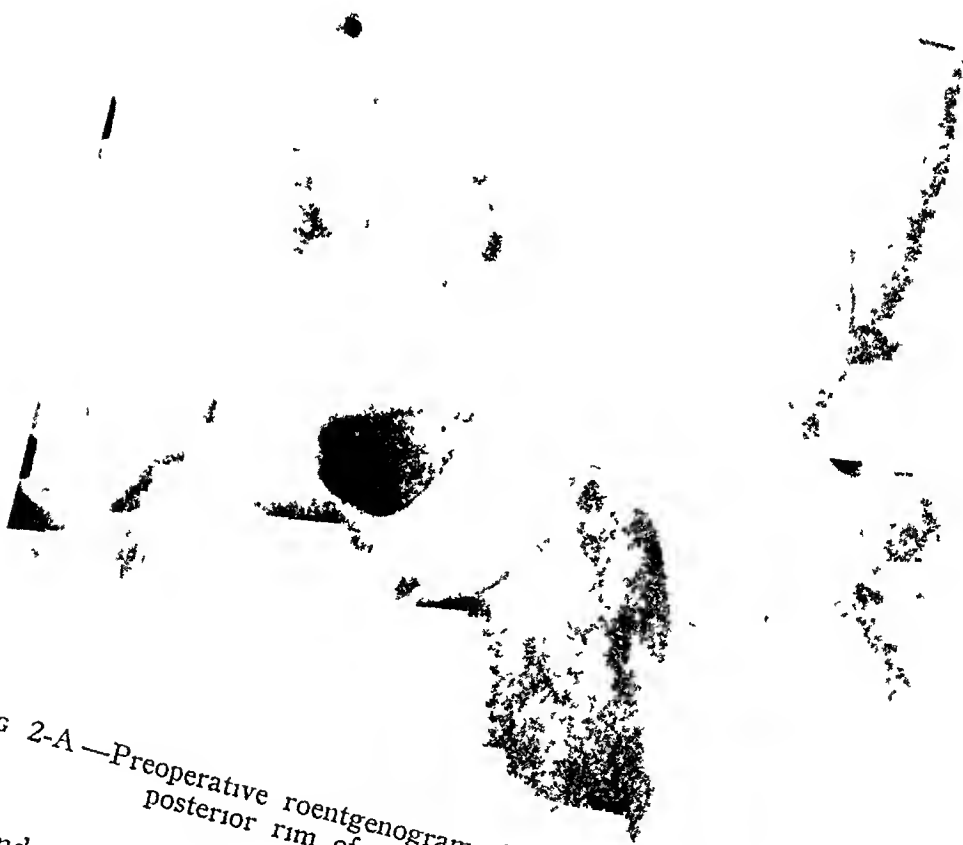


Fig 2-A—Preoperative roentgenogram showing fracture of the superior-posterior rim of the acetabulum (Case 18)

femoris, and the rectus femoris. After irrigation and curettage to remove all the blood obscuring fracture lines, the main fragment was replaced in anatomic position with its attachments to capsule and anterior iliofemoral ligament intact. Although the fracture was clearly visible by this approach, a transfixing screw could not be inserted at right angles to the fracture site. This was accomplished by a lateral stab wound in the gluteus medius large enough to permit the introduction of a long drill point screw driver at right angles to the middle of the fracture line. The fragment dovetailed and was compressed so accurately into place that the fracture line was hardly visible in the postoperative roentgenogram (Fig 2). Fractures of the superior rim, the strongest portion of the acetabulum, are rare,⁵⁴ and a case similar to this one has not come to our attention in the literature.

Fractures of the posterior rim of the acetabulum are more common and are easily repaired by the posterior approaches which we have used with the same success as many others in recent years⁵¹

CENTRAL FRACTURES OF THE ACETABULUM

The eight fractures of the acetabulum in this series (Table I) in which the rim of the acetabulum was largely intact and the head remained in the joint



FIG 2-B — Roentgenogram showing anatomical repair of the joint surface and internal fixation of the fracture, one week postoperative (Case 18). The screw should penetrate the inner table of the pelvis to obtain reliable immobilization of the fragment.

cavity are classified as central fractures. In four instances there was no displacement. In three instances there were fractures of the dome of the acetabulum with displacement of the inner table of the pelvis for a distance of about the width of the cortex. One case (Case 28) represented the typical fracture of the anterior acetabulum and the body of the pubis with intrapelvic protrusion of the head of the femur and wide displacement of the inner table of the pelvis. The patients were immobilized in a Thomas splint or a spica, with the joint in neutral position and were evacuated from the combat zone without manipulation or other treatment.

Conservative Treatment On their arrival in general hospitals in the communication zone after further roentgenologic studies, all the patients were suspended in skeletal traction for six to eight weeks. In the case

of intrapelvic protrusion of the head of the femur (Case 28), reduction was accomplished by the use of a trochanteric vertical Kirschner wire placed just inside the lateral cortex. The head of the femur was manually pulled out into normal relationship with the rim of the acetabulum by the use of the large size wire-tautening bow for a handle. The hip was suspended in a Balkan frame for eight weeks with five pounds' lateral traction and ten pounds' bilateral longitudinal skin traction through the lower extremities. The ipsilateral side of the bed was elevated slightly for lateral countertraction. Although the displacement of the inner table of the cortex was not modified by this treatment, the fracture site filled in with abundant callus within the four months that the

patient was under observation. The failure of the fracture site to follow after the extracted femoral head is similar to the observations made in the civilian cases reviewed (Table II) and is apparent in the "before and after" pictures of almost every case reported in the literature (Fig 3)

EXTENSIVE COMMINUTED FRACTURES OF THE ENTIRE ACETABULUM

In the three cases in this series (cases 29, 30 and 31) in which comminuted fractures involved all portions of the acetabulum, the joint was disorganized and incongruent. In two of the three patients in the group there was an associated fracture of the ipsilateral femur.

Emergency management was limited to prophylactic treatment for shock. The patients were immobilized in hip spicas in slight abduction and were immediately evacuated from the combat zone.

Conservative Treatment All three patients were treated conservatively in traction. Skeletal traction by means of a Kirschner wire through the supracondylar region aligned the fractures of the shaft of the femur but had little effect upon the fractures of the acetabulum. It was assumed from the beginning in these cases that arthroplasty or fusion of the joint would be necessary at a later date.

FOLLOW-UP STUDIES

The status of 14 of the 16 patients in this group could be determined at the end of two years by means of personal letters from them or from their physicians, by reports of examinations in United States Army hospitals, and, occasionally, by firsthand observation. Unfortunately, it was not possible to locate the single patient with intrapelvic protrusion of the head of the femur. The results of fractures of the acetabulum in military personnel are to be compared with similar fractures in a group of patients, including two similar cases of intrapelvic protrusion, from the Fracture Service of the Massachusetts General Hospital (Table II).

At the end of two years, 11 of the 14 military patients followed had no serious disability. Many, however, complained of mild pain, snapping or clicking sensations in the joint, stiffness early in the morning, and discomfort from lifting heavy objects. Patients with displaced fractures of the supero-posterior rim of the acetabulum appeared to have more symptoms and more disability than those with anterior rim or central fractures. One patient (Case 19) with an unreduced fracture of the posterior rim had severe pain and some limitation of motion at the extremes of the normal range in all directions. One patient (case 18), whose joint was accurately repaired at open operation, in contrast, had a normal hip. In both these cases the displaced fragment of the rim was relatively large. If the fragments were smaller or thinner and carried less of the articular cartilage with them, the important function of the joint would probably not be affected, regardless of whether or not they were replaced. The three patients with extensive fractures of the acetabulum and destruction of the joint cavity had ankylosis and complete disability two years after the injury.

TABLE II—*Selected Fractures of the Acetabulum at the Massachusetts General Hospital 1932 to 1946*

Unit No	Age	X-ray	Treatment	Weight-bearing (months)	Follow-up
493496	14	Central fracture, slightly displaced	Traction 4 weeks	2	Normal hip at 2 years
78702	60	Central fracture, slightly displaced	Traction 4 weeks	3	Normal function at 2 years but tires easily because of mild pain
345913	64	Central fractures, medial displacement body of pubis and anterior acetabulum	Bed rest	3	Moderately painful hip, narrowing of joint space in X-ray
320953	50	Central fractures, medial displacement body of pubis and anterior acetabulum	Bed rest	3	No symptoms at 1 year
514457	40	Central fractures, medial displacement body of pubis and anterior acetabulum, intrapelvic protrusion of head of femur	Lateral and longitudinal traction, 4 weeks	3	Normal function, slight limitation of flexion at 1 year
353469	22	Central fractures, medial displacement body of pubis and anterior acetabulum, intrapelvic protrusion of head of femur	Traction	3	Normal function, slight limitation of flexion at 3 years
537224	52	Central fracture, comminuted, bursting type	Open reduction	12	Painful hip, moderate ankylosis at 1 year

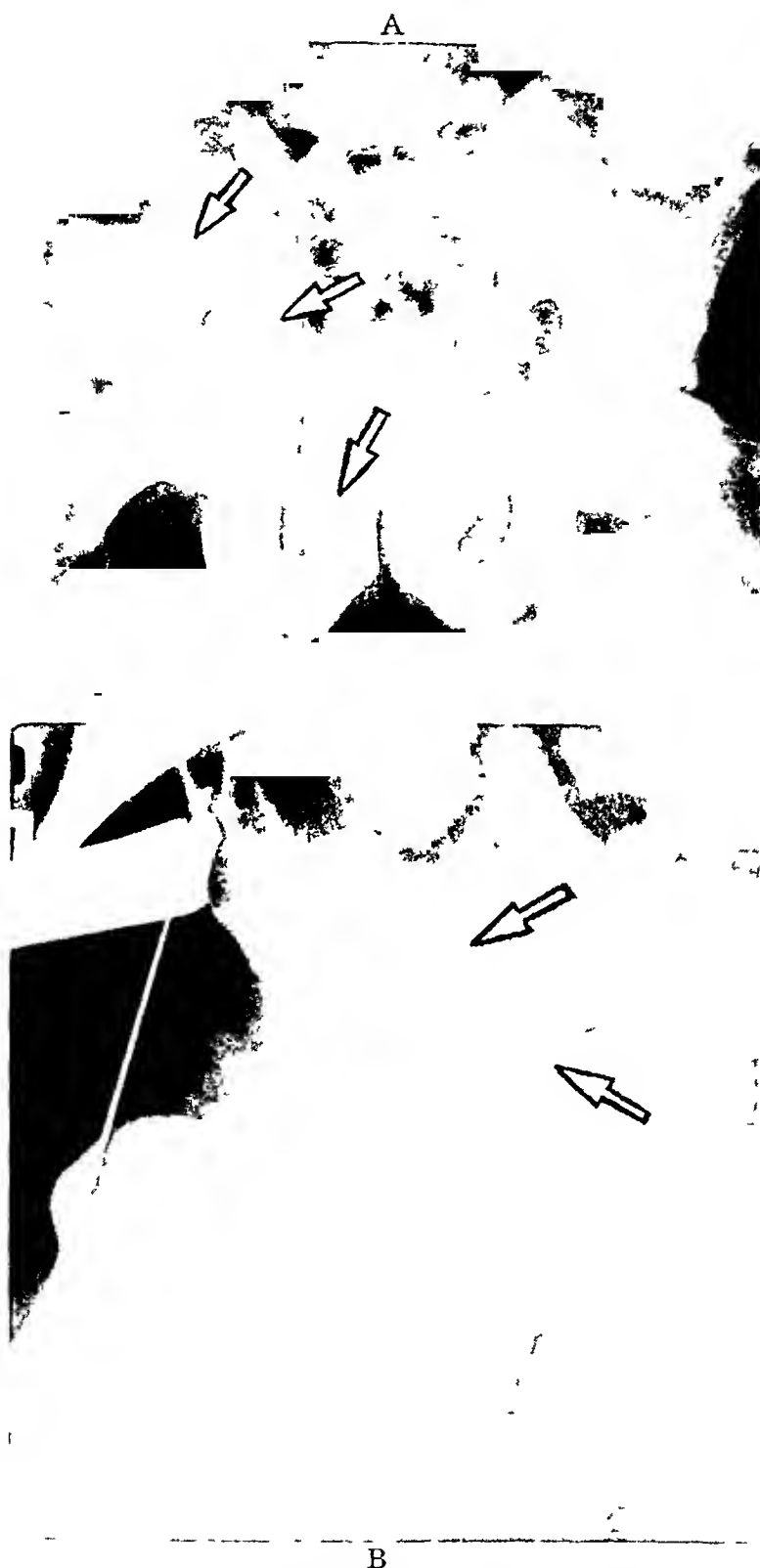


FIG 3-A—Roentgenogram showing central fracture of the acetabulum with intrapelvic displacement of the anterior rim of the acetabulum and the inner table of the pelvis. The displacement hinges on the fracture of the superior ramus of the pubis indicated by the lower arrow (Case 28). Other arrows indicate the main fragments.
 FIG 3-B—Roentgenogram of the fracture in Figure 3-A showing the head of the femur withdrawn from the fracture site by lateral skeletal traction through a vertical Kirschner wire in the greater trochanter. The main fragments of the fracture do not follow the head in this type of fracture (Case 28).

In two of the seven fractures of the acetabulum studied from the fracture service of the Massachusetts General Hospital (Table II), the head of the femur protruded into the pelvic cavity, and roentgenograms showed the typical features of displaced fractures of the body of the pubis and the internal table of the pelvis. Treatment was the same as in case 28 of the military series, and in neither instance was there any disability at the end of one and three years respectively. It is difficult to understand, in this type of central fracture, why even when there is intrapelvic protrusion of the head of the femur, healing occurs without functional disability, regardless of the displacement of the inner table of the pelvis. The explanation may be that the fractures in these cases affect the anterior rim, a nonessential part of the joint, and that the vital posterior and superior portions of the horseshoe-shaped articular cartilage are spared. When, on the other hand, intrapelvic protrusion of the head of the femur is associated with extensive fractures of the acetabulum and bursting of the triradiate seam of ilium, ischium and pubis, or with distortion of the rim of the acetabulum, the functional result is very poor. The division of the cases of central fractures into these two categories would explain the discrepancy in results^{1, 3, 5, 19, 27, 31, 32, 37, 43, 45, 58} reported in the literature for the treatment of this type of acetabular fracture.

DISCUSSION

The experience gained in the treatment of the cases reported in this paper supports the impression received from a survey of the literature that the seriousness of a fracture of the acetabulum depends upon whether the superior and posterior portions of the lunate articular cartilage are defective. Open reduction has been advocated^{6, 13, 32, 37, 57} for rim fractures in recent years, the principle being that reposition of the joint fragments is as necessary in the hip as in injuries of other weight-bearing joints. Previously, many writers accepted the imperfect results of conservative treatment because of the formidable nature of operative treatment and lack of knowledge of late degenerative changes in the joints.

Central fractures of the acetabulum, including cases with intrapelvic protrusion of the head have been generally considered together and treated as one problem in various ways. The cases with intrapelvic protrusion of the head of the femur have excited a great deal of interest and there are now many isolated case reports upon which present methods of treatment are well-established. It is not unusual that these injuries should occur in jeep accidents. The lesion can be produced experimentally and accidentally by a blow on the flexed knee transmitted to the head of the femur⁴⁷ and possibly even by indirect forces of abnormal muscle action during convulsions from shock therapy.²² More commonly, it is incurred by a blow on the greater trochanter. Variations in the pattern of the lesion and possible inclusion of various parts of the rim of the acetabulum, may be determined by the degree of abduction of the limb and the amount of internal and external rotation of the head of the femur. If it is in external rotation, a blow on the greater trochanter would drive the

head of the femur into the anterior portion of the acetabulum where intra-pelvic protrusion is possible with minimum damage to the weight-bearing lunate-shaped articular cartilage

Satisfactory results have been reported by the use of a variety of systems of treatment capable of extracting the head of the femur from the pelvis. One of the earliest methods reported to give uniformly satisfactory results was the abduction spica of Whitman, in which the greater trochanter is used as the fulcrum^{8, 17, 23, 25, 29, 48, 56}. The favorite among the more modern technics is lateral or combined lateral and longitudinal traction. Slings or pressure pads applied to the medial aspect of the upper thigh^{26, 39, 41, 42, 53} and the Jahss cast³⁵ have been employed for lateral traction, but skeletal traction obtained through a trochanteric screw^{14, 33, 34, 44} or a Kirschner wire^{18, 24, 40} or a Steinman pin³⁸ is more comfortable for the patient. Self-retained traction devices with a Thomas-Jones abduction splint,⁴ a windowed hip spica,^{34, 46} or Hoke's apparatus⁴⁹ facilitates the nursing care.

All of these methods have proved capable of retaining the normal position of the head of the femur on the lunate articular cartilage of the acetabulum until the fracture heals. On the other hand, the "before and after" roentgenograms of almost all of the cases reported in the literature show, as in the cases reported herewith, that the displaced inner table of the pelvis seldom, if ever, follows the head of the femur when it is drawn out of the fracture site. It has been reported that the fracture can be modified by manipulation through the rectum,^{9, 15, 26} but the results are not striking and the method is discouraged by some surgeons.²⁸ Open reduction is practical in very severe cases through an anterior iliofemoral approach, exposing the true pelvis. Engel¹⁶ repaired the roof of the acetabulum by this method, tapping the bone flap of the inner table into place with a bone set and wooden mallet. Levine³⁵ reduced an unusually large fragment of bone and applied a steel plate held in place by four screws along the anterior pelvic rim. Open operations are also described by Lexer,³⁶ and König.³⁰

It is difficult to evaluate the results reported in both the old^{21, 52} and the new^{11, 20, 57, 58} literature, because exact limits of the injury are not frequently clearly described. The author's illustrations suggest, however, that the poorest results were secured in cases in which the rim of the acetabulum was involved and the joint cavity was left permanently incongruous and enlarged in depth and width. Good functional results were usually reported in the cases in which displacement was limited to a large single fragment of the body of the pubis and the inner table of the pelvis and in which the head of the femur was dislocated into the fracture site.^{3, 20, 27} In such cases the anterior acetabular fossa regenerates by abundant callus and fibrocartilage, which readily grow across the fracture site in this highly vascular portion of the skeleton.

The true incidence of degenerative or traumatic arthritis and the late results of these and other types of injuries of the acetabulum are known only in isolated, poorly documented cases which come to the attention of the

surgeon many years after the injury. Complete avascular necrosis seems to have been reported in one case, two to three years after an injury in which the head of the femur was virtually locked in the fracture site,¹⁴ and two other severe cases^{2, 7} in which one might assume ischemia of the capsula reflexa was the cause.

SUMMARY

1 Sixteen cases of fractures of the acetabulum which occurred in military personnel and seven similar cases, which were studied on the Fracture Service of the Massachusetts General Hospital, are reported.

2 Fractures of the superior and posterior rims of the acetabulum of significant magnitude almost always resulted in some disability, but good function of the joint was obtained in one case after open reduction and accurate internal fixation.

3 Central fractures of the acetabulum can be classified in two groups, according to various roentgenogram patterns of the traumatic lesion and the functional results achieved at the end of two years. A Central fractures limited to the pubic portion of the acetabulum and the descending ramus of the pubis, even with intrapelvic protrusion of the head, responded well to conservative treatment and showed an excellent functional result after one to three years. B Central fractures bursting the triradiate line of the acetabulum were impossible to reduce by conservative methods and resulted in great disability. Fusion or arthroplasty was advised in three such cases after two years.

4 The differences in end-results can be explained on the basis of cumulative, experimental, operative, and roentgenologic observations, as well as by end-results. All the evidence is to the effect that fractures of the pubic portion of the acetabulum are chiefly lesions of the anterior rim, which is not essential to the function of the hip joint while, on the other hand, stellate or bursting fractures involve or distort the lunate superior and posterior articular cartilage of the acetabulum which is necessary for normal weight-bearing.

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EXPERIMENTAL STUDIES OF ALGINATES AS HEMOSTATICS*

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THE THREE ABSORBABLE hemostatic packing materials which have had extended trial in clinical surgery are, in order of their introduction, human fibrin foam, oxidized cellulose—in the form of gauze or cotton—and gelatin sponge. There are minor differences in the immediate hemostatic effect of these different materials and in the technics of their surgical use, but they are all non-irritating in the tissue, non-toxic and absorbable. None of these can be sterilized by autoclave, and should a material be developed which had this advantage and also the desirable properties of the other agents it would be a welcome addition to our surgical armamentarium.

It was suggested that alginic acid or its salts might answer this purpose. Alginic acid is a naturally occurring organic acid derived from seaweed (*Laminaria digitata*) with a formula closely resembling cellulose¹. The alginates had already been developed for wide commercial usage. Woven and spun preparations, gauze and stockinette were available. As is often the case with what is thought to be an original idea, independent investigations were undertaken in several different laboratories. The credit for the first experimental observations goes to Blaine, of England, whose paper, although not published until January 1947, was submitted to this journal for publication in January 1946¹.

Our own studies began about that time and we were accelerated because we had the privilege of reading Major Blaine's article in manuscript. As he says in his text, "Exigencies of the service in wartime have made it impossible to conduct a more complete examination of the many problems at issue. It has been shown, however, that alginates possess certain properties which make their surgical use attractive." There was no doubt in our minds, therefore, that the alginates held considerable promise. We had hoped to obtain directly from Major Blaine some of the alginate gauze he had employed in his studies for comparison with that submitted to us by the chemists who had suggested its possible surgical application, comparison particularly in regard to texture and tensile strength. We also planned to run a comparative series of experiments on oxidized cellulose and this new material, with especial reference to the immediate effective hemostatic properties of each agent, and the tissue reactions. Somewhat later it seemed imperative that the pharmacology of the alginates should be studied in detail for comparison with oxidized cellulose and this was undertaken by another group of investigators². Stimulus was also given to this study by the publication of a letter to the editor in *Science*, May 1946, in which Smith³ reported the styptic action of local application of

* The work described in this paper was done under a grant from Johnson & Johnson, New Brunswick, N J

alginic acid powder in 100 cases of tooth extraction and minor oral surgery. The dose would obviously be small in these cases and presumably most of the wounds were open.

The alginates submitted to us by the Research Laboratories of Johnson and Johnson were processed in an effort to maintain tensile strength and achieve ease of handling in actual surgical manipulation. Early samples of varying calcium content were submitted, and in addition, a sizing agent as well as a buffering solution were sometimes used. The chemical analysis shown in Table I makes it clear that variations in tissue reaction could therefore be attributed to a number of factors.

With all samples it was observed that the tensile strength was not as good as that of oxidized cellulose, and that the combination of the material with citrated blood resulted in a soft, brownish-black, mushy paste more difficult to handle with forceps than the black gelatinous mass so formed with oxidized cellulose. It was expected, however, that if other features were satisfactory, minor changes in preparation might alter these physical properties. The

* METHOD OF PREPARATION

Calcium Alginate Gauze

31B, 35A, 35C — Treatment 15 minutes in HCL, pH 1.5. Washed, buffered, 15 minutes, washed, air-dried.

100 (4) Demer Calcium Alginate Stockette

62D1, 69 — Treatment Washed in water. Extracted with ethyl alcohol and ether (separately), treated in HCL (0.974N) 1 hour, washed and treated 2 hours in an excess of 0.2N CaCl_2 , washed. Buffered, air-dried.

73 Treatment Similar to 62D1 and 69 but not buffered. Washed with tap water, pH 7.4, dried at 45°.

62B1, 65 — Treatment Washed in water. Extracted as 62D1 and 69, treated overnight in 0.974 N HCL, and washed CL free. Buffered, washed, air-dried.

64 — Treatment Approximately normal HCL 1 hour. Washed once and treated in an equal quantity of fresh acid 30 minutes. Washed. Buffered 20 minutes. Washed, air-dried.

41-116 — Treatment Dilute HCL until calcium content reduced to 0.15%. Buffered.

41-118 — Treatment Similar to 41-116 but alcohol-ether extracted to remove Fixanol.

41-120 — Treatment Warm water (40° C). Calcium content reduced with dilute HCL (3% then 1%). Washed with cold water. Dried at 60°.

41-151 — Treatment Extracted with acetic acid to remove Fixanol. Dilute HCL to remove calcium. Alginic acid thus derived oxidized with HIO_4 , with partial conversion of the secondary alcohol groups to aldehyde groups. Treated with dilute HNO_3 , air-dried.

41-152 — Treatment Similar to 41-151 but Fixanol not extracted.

89-31, 89-32 — Treatment Fuming HNO_3 at room conditions 1 hour. Washed free of acid, air-dried.

affinity of the alginic acid for hemoglobin as demonstrated by the laked blood test was similar to that of oxidized cellulose

In our earlier studies of oxidized cellulose^{4, 5} one of the standard tests was solubility in 0.15 Molar solution of sodium bicarbonate. Satisfactory preparations of oxidized gauze and oxidized cotton dissolve completely without residue. No animal tests were undertaken on samples which showed 1e-

TABLE I—*Alginates Tested*

Lot No	Weave	% Free COOH	% Ca	Buffered* %K	Nitrated %N	Fixanol† Sizing	Sterilization
31B	Gauze	22.14	3.03	Approx 2.5		+	Steam
35A	"	"	2.45	"		+	"
35C	"	"	3.06	"		+	"
62D1	Stockinette	"	2.80	"		0	"
69	"	"	1.82	"		0	"
73	"	"	2.81	0		0	"
62B1	"	"	0.25	"		0	"
65	"	"	0.58	"		0	"
64	"	"	0.19	"		+	"
41-116	"	"	0.10	Analyzed 2.54		2%	"
41-118	"	"	0.10	"		0	"
41-120	"	"	0.10	Approx 2.5		+	"
41-151	"	"	0.0		0.2	0	Formaldehyde 0.11 res
41-152	"	"	"		0.3	2%	"
89-31	"	16.3	"	0.0	4.0	Trace	Formaldehyde
89-32	"	14.6	"	"	4.68	"	"

*Potassium acid phthalate solution 0.05 Molar pH 4.0

†Sizing Fixanol—octyl pyridium bromide. A finishing agent used in the manufacture of alginate yarn to prevent sticking together of the monofilaments.

TABLE II—*Standard Rat Tests on Calcium Alginate Gauze*

Lot No	% of Ca Content	No. of Animals	Days Post-Op	Absorbed	Inflammation	Fibrosis	Conclusions
31B	3.03	5	2—28	0	2+	1+	Unsatis
35A	2.45	5	7—21	0	1+	1+	Unsatis
35C	3.06	5	7—21	0	2+	1+	Unsatis
62dl	2.80	4	4&7	0—±	Contam	Contam	Repeat*
69	1.82	6	2—7	±	1+	2+	Unsatis
73	2.81	5	2—7	±	±	±	*Also unsatis
62B1	0.25	6	7	Completely	0	0	Satis
64	0.19	6	2	Completely	Min		Satis
65	0.58	4	2	Completely	Min		Satis

sidual fibers of material. In applying this test to calcium alginate it also was found to be soluble in 0.15 Molar NaHCO_3 , but there was a precipitate of calcium carbonate which was not to be confused with insoluble residue. All samples tested were completely soluble.

Affinity for hemoglobin, and solubility tests having borne out the expectation that alginic and cellulosic acid were somewhat similar in behaviour as

well as structure, tests for tissue reaction were then undertaken. The first tests were for absorption and tissue response and were conducted according to the technic devised by Lattes Frantz.⁶ This was reported in this Journal in 1945. It consists of aseptic implantation of materials under scrutiny in the subcutaneous tissues of the back of rats. In our own previous studies, fibrin foam, gelatin sponge, oxidized cellulose and a large number of other substances had been subjected to this "rat test." Only the first three were found to be

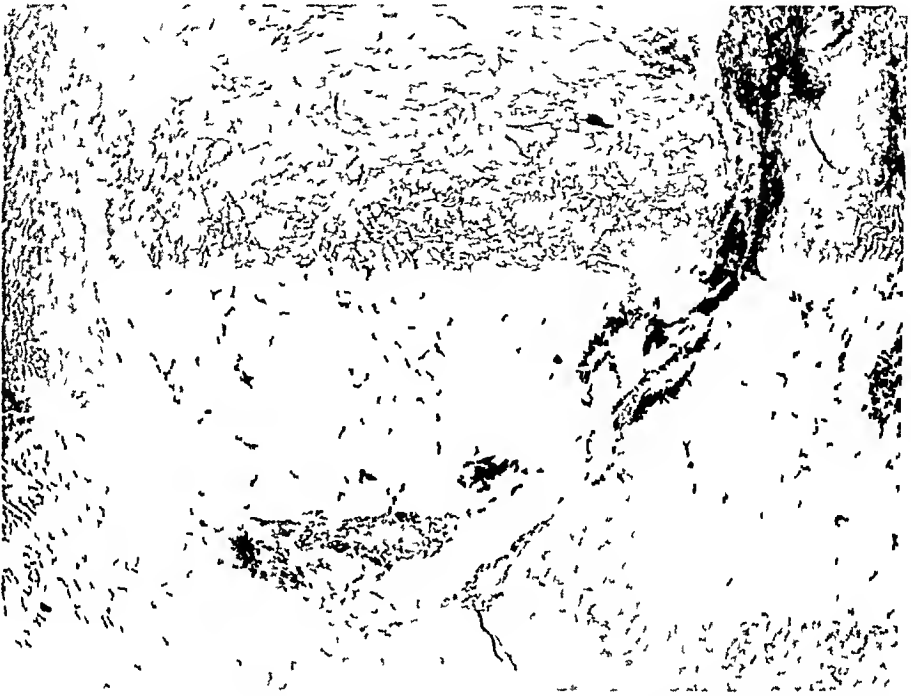


FIG 1—S. P. 25509 Photomicrograph, X38, of di-aldehyde alginate gauze (41-151) in experimental wound of upper pole of kidney. Dog—42 days. Large amount of unabsorbed material. A broad zone of fibrous scar tissue separates kidney parenchyma from the hemostatic packing. On higher magnification this tissue is seen to contain many hemosiderin laden phagocytes. There are no polymorphonuclear leukocytes and no foreign body giant cells.

both non-irritating and completely absorbed. In testing the alginate acid preparations by this method it was thought unnecessary to run simultaneous controls of oxidized cellulose since detailed studies had already been reported (4 and 5) and the techniques used were the same. The results of the first series of rat tests are shown in Table II.

These early promising samples (62B1, 65 and 64) led us to study the effectiveness of the new materials in experimental hemorrhage. It will be seen from Table II that the unsatisfactory samples were those of higher calcium content, and the trials of hemostasis were accordingly made on approximate duplicates of 62B1, but with even lower calcium content (41-116, 41-118 and 41-120). Again the tests employed were those by which oxidized cellulose had originally been studied and which have been reported in detail (4

and 5), i.e. wounds of kidney and spleen. Immediate hemostatic effect in an experimental or clinical wound is obviously not subject to exact measurement. The wounds of the kidney in this technique are made as nearly comparable as possible, one in the upper and one in the lower pole. The capsule is incised, a clamp is thrust into the parenchyma and spread so that brisk bleeding ensues. The wound is then lightly packed with the hemostatic agent to be studied. It was in such wounds that we first observed that oxidized gauze



FIG 2—S P 25509 Photomicrograph, X38, of control wound, lower pole of same kidney as Fig 1, packed with oxidized cellulose. The foreign body in the capsule is the markingsilk suture. No gauze is seen. The site of the implant at this magnification is characterized by diffuse dark staining. There is no unabsorbed material. In higher magnification this zone is almost entirely composed of phagocytes, some hemosiderin laden. The bulk show the basophilic staining characteristic of cellular reaction to oxidized cellulose. There is almost no scar tissue except the linear extension of the wound seen at the base on the right, and slight fibrous proliferation in the capsule.

had a specific hemostatic effect. Hemorrhage was more rapidly controlled with this gauze than with plain gauze. The alginate preparations when compared with oxidized cellulose exhibited very little hemostatic effect. The hemorrhage was controlled in these standard kidney wounds chiefly by the presence of packing and not by any evident styptic action.

Further confirmation of this was obtained in standard tests in shallow surface defects in the spleen where the packing effect is absent. Here little styptic action of alginate was noted, although the preparation without sizing was somewhat more effective than those with it. Controls here were also made with oxidized gauze (Table III).

TABLE III—Comparative Studies in Experimental Hemostasis and Tissue Reactions in Dogs with Oxidized Cellulose and Algue Acid

Lot No	Chemical Analysis	Autopsy Days Post-Op	Immediate Hemostatic Effect in Spleen and Kidney		Tissue Reactions in Kidney		Evidence of Inflammation	Comment
			Alg	Ox Cell	Alg	Ox Cell		
1	41-116 (Chenoweth B) Buffered Sizing Ca 0.1%	17	1+	4+	3+	4+	0	Progressive downhill course
2	41-116 "	40	±	4+	2+	4+	0	Sick for 6 days post-op
3	41-118 Buffered No sizing Ca 0.1%	4	2+	4+	0	0	3+	Peritonitis No culture
4	41-118 "	28	2+	4+	2+	4+	0	Sick for 5 days post-op
5	41-120 Not buffered No sizing Ca 0.1%	28	±	4+	4+	4+	0	Very sick for 5 days post-op
6	41-120 "	40	±	4+	2+	4+	0	Loss of weight and strength throughout
7	41-151 (Chenoweth C) Di-aldehyde No sizing Ca 0%	42	2+	4+	2+	4+	0	Poor health throughout post-op course
8	41-152 (Chenoweth C) Di-aldehyde Sizing Ca 0%	7	±	4+	±	±	1+	Died Antemortem clot rt auricle

As the immediate hemostatic effect of the alginates did not compare favorably with that of oxidized cellulose, further chemical modifications of the preparations was proposed in order to improve this property. One of these new preparations was the di-aldehyde of alginic acid (41-151 and 41-152) and this was moderately effective in immediate hemostasis (Table III). It was not a promising modification, however, because the material, originally proposed to facilitate sterilization, no longer had the advantage of being sufficiently heat resistant to be sterilized by autoclave. Another preparation suggested, nitrated sodium alginate, was also too unstable for autoclave. In spite

TABLE IV—*Standard Rat Tests on Recent Preparations*

Lot No	Description	No of Animals	Days Post-Op	Absorbed	Inflammation	Fibrosis	Conclusion
41-120	Alginic acid Not buffered No sizing Ca 0.1%	5	2—8	Completely	Variable	1+	Unsatis
41-151 (Chenoweth C)	Di-aldehyde No sizing Ca 0%	5	2	Completely	0	0	Satis
41-152 (Chenoweth C)	Di-aldehyde Sizing Ca 0%	5	2	Completely	0	0	Satis
89-31 (Chenoweth D)	Nitrated sodium alginate with sizing	4	1—7	Completely	1+	0	Toxic*
89-32 (Chenoweth D)	Nitrated sodium alginate with sizing	4	2—5	Completely	±	0	Toxic†

*1 Death—24 hours 2 Animals lethargic until sacrificed

†3 Deaths—2, 2 and 5 days 1 Animal lethargic when sacrificed at 3 days

of this disadvantage a second short series of rat tests was undertaken as a preliminary to possible further studies on hemostasis. The results are shown in Table IV. At the time these tests were made we were apprised of the observations of Chenoweth on the toxicity of the material in cats.² Detailed autopsy studies were not attempted on the rats in this last series because post-mortem changes were often advanced, and there were further depredations by cage mates. In comparison, however, with several hundred previous rat tests the morbidity and mortality rate in this group was considered significant.

With this knowledge, a careful re-reading of Blaine's article led us to the belief that although the cats he subjected to liver lacerations had survived when the bleeding had been controlled with alginates, there had been early toxic effects comparable to those reported by Chenoweth. Moreover, the polymorphonuclear leukocytic response which the author described in the local tissue reactions, had been duplicated in many of our own observations, and indicated a greater degree of irritation caused by the alginates than by oxidized cellulose.

SUMMARY AND CONCLUSIONS

1 Local tissue reaction to various spun and woven preparations of alginic acid and its derivatives have been studied in a series of rat tests. Although some of the preparations evoked a minimal inflammatory response, several were apparently irritating and engendered a considerable fibrous tissue replacement when finally absorbed. The most favorable preparations were slightly more irritating than oxidized cellulose. That they were also toxic even when introduced thus, in solid form, to be absorbed slowly, was suggested by the high mortality rate among these rats, although detailed study of the toxicology was not undertaken here.

2 The immediate hemostatic effect of alginic acid preparations was contrasted with controls of oxidized gauze in the spleen and liver of dogs. There was a marked difference in this property, control of hemorrhage being often difficult to obtain with alginate when oxidized cellulose was immediately effective. Study of these organs at autopsy showed in general, more inflammatory and fibrous tissue response to the alginates than to oxidized cellulose. If anything, the absorption time of the former was longer, but this was not checked in detail. The toxic effects at presumably lower dose levels than those employed by Chenoweth in cats suggests the possibility that the dog is more susceptible to the toxic effects of the alginates than the cat.

3 It was concluded that the advantage of sterilization by autoclave was outweighed by the less effective hemostatic action and by the toxic properties of the alginates, and that further experimental study was not warranted. It was not thought safe to propose these new preparations for trial in clinical surgery.

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THE TOXICITY OF SODIUM ALGINATE IN CATS*

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AN ABSORBABLE, hemostatic and readily manufactured surgical gauze which can be sterilized by autoclaving can be prepared from alginic acid, the product of certain seaweeds. A report on the nature and experimental surgical use of such gauze has been made recently by Blaine¹, who found it to be readily absorbed and concluded that it was a useful hemostatic agent of wide applicability. A report by Solandt² indicates that the sodium salt of alginic acid possesses considerable toxicity for rabbits.

Because of the usefulness of absorbable surgical gauzes, the discovery of a material which, on manufacturing grounds, is as suitable as alginic acid, is very important. However, in view of the toxic effects reported by Solandt it appeared necessary to carry out a more extensive examination of the pharmacology of alginates. The present study is an examination of the effects of the administration of alginic acid and some of its derivatives. These are listed and described in Table I.

A THE TOXICITY OF COMMERCIAL SODIUM ALGINATE (41-125)

This material was obtained as a powder which was soluble in physiologic saline to the extent of one per cent, forming a viscous solution. Three cats were injected intraperitoneally with 250 mg/kg and two with 100 mg/kg. Larger doses could not be given because of the volume required. These animals were followed for 10 days and then sacrificed with ether (see Table II). In general, the toxic effects produced were not related to the dose of alginate administered. Only one animal, one which received 250 mg/kg, was moribund at the time of sacrifice. This animal failed to eat after the injection and became progressively more depressed. During this 10 day period the animal manifested proteinuria and hematuria. Although on examination of the abdomen it appeared that most of the injected alginate was still present, on microscopic examination the kidney tubules were found to be completely occluded by erythrocytes, indicating considerable absorption and toxicity.

The other animals of this series vomited frequently on the day of injection and were depressed and disinterested in food on the following day. All animals showed definite depression of cortical reflexes (placing)⁴ and some ataxia. In two cases recovery occurred in about five days while in the remaining three animals the abnormalities persisted until sacrifice.

Urine secretion was suppressed in all animals for one to three days, followed by the secretion of small amounts of urine containing considerable protein. Both volume and protein content had returned to normal three or four days after the injection.

* *Placing Reactions* A group of cortical reflexes concerned with proprioceptive maintenance of posture.

** The expenses of this investigation were defrayed by a grant from Johnson and Johnson.

On examination of the sacrificed cats it was found that absorption had been very irregular, probably accounting for the absence of a relation between the dose injected and the effects produced. The peritoneum, however, showed no signs of irritation. Apart from a small hemorrhagic area in one lung, found microscopically to be associated with a vein occluded by hyaline, palely basophilic material (alginic acid?), no gross damages were noted. Microscopic examination of the kidneys revealed extravasation of the blood into the tubules, varying in degree from slight to extreme. The tubular epithelium

TABLE I—*Characteristics of Substances Examined**

Sample Number	Chemical Nature	Supplied as	Partial Analysis per cent†					
			COOH	Ca	K	N	CH O	Nitration
41-116	Alginic acid	Gauze‡	22.1	0.10	2.5		None	None
41-125	Sodium alginate	Powder		0.0	0.0		None	None
41-151	Di-aldehyde alginic acid	Gauze	22.1	0.0	0.0	0.2	0.11	None
41-152	Di-aldehyde alginic acid (contains 2% octyl pyridium bromide, a sizing agent)	Gauze	22.1	0.0	0.0	0.3	0.11	None
89-31†	Decarboxylated, nitrated alginic acid	Gauze	16.3	0.0		4.0	Trace	38
89-32†	Decarboxylated, nitrated alginic acid	Gauze	14.6	0.0		4.7	Trace	45

*Aqueous solutions are negative to the usual tests for protein and reducing substances

**Analyses supplied by the manufacturer

†Reduce Benedict's solution

‡Woven in a tubular form known as stockinette

TABLE II—*Toxicity of Commercial Sodium Alginate Solution Following Intraperitoneal Injection (41-125)
(By Single Injection)*

Experiment Number	Dose mgm /kg	Died (D) or Sacrificed (S)	Duration of Experiment	Degree of Effect	Comment
15	250	S	11 days	4+	Moribund
17	250	S	9 days	1+	
18	250	S	9 days	1+	
16	100	S	11 days	2+	
19	100	S	11 days	1-2+	

The presence of one or more of the following conditions was used to establish the 'degree of effect'

1+ = slight ataxia, depressed placing reflexes slightly depressed

2+ = ataxia, placing reflexes depressed, moderate proteinuria

3+ = prostrate, extreme proteinuria, smaller intracardiac clots

4+ = Dead or moribund, anuric, larger intracardiac clots

appeared to be slightly damaged but assurance on this point is not possible because of the distorting effect of the fat content of the normal cat tubules. The liver lobules showed some necrosis, particularly of the central type, while in two animals which had received doses of 250 mg/kg there were areas in which the nuclei were darkly stained and pyknotic and the cytoplasm of large areas had a fused, amorphous appearance and, although still acidophilic, were much more intensely stained.

B THE TOXICITY OF ALGINATE GAUZE (41-116) *

This sample was a gauze, which consisted of the partial calcium salt of alginic acid suitably prepared for surgical use. A five per cent solution was prepared by dissolving the gauze in sodium bicarbonate. The solution, although somewhat viscous, was easily injected intravenously and intraperitoneally in cats. The results of these experiments are presented in Tables III and IV. It is apparent that the preparation was decidedly toxic.

The animals, following injection by either route, rapidly became depressed, vomited frequently and showed no interest in food on the day of the injection.

TABLE III—*Toxicity of Alginic Acid (41-116) Solution Following Intraperitoneal Injection (By single injection)*

Experiment Number	Dose mg /kg	Died (D) or Sacrificed (S)	Duration of Experiment	Degree of Effect	Comment
9	500	D	1 day	4 +	Antemortem clot
10	250	D	1 day	4 +	" "
14	250	D	1 day	4 +	" "
12	100	S	7 days	3-4 +	" "
13	100	S	7 days	1 +	
8	25	S	10 + days	1 +	
11	25	S	10 + days	1 +	

TABLE IV—*Toxicity of Alginic Acid (41-116) Solution Following Intravenous Injection (By Single Injection)*

Experiment Number	Dose mg /kg	Died (D) or Sacrificed (S)	Duration of Experiment	Degree of Effect	Comment
2	500	D	5 Days	4 +	
3	500	D	1 day	4 +	
4	500	D	2 days	4 +	
6	500	D	4 days	4 +	Antemortem clots
5	316	D	1 day	4 +	" "
1	250	D	2 days	4 +	Anuric
7	250	D	2 days	4 +	Antemortem clots

The following day many of the animals were moribund, while all except those receiving the smallest doses were markedly depressed. Central nervous system function was obviously impaired, for ataxia was extreme in those animals which could walk at all, placing and righting reflexes were depressed or absent and the animal's reactions to noxious stimuli were feeble.

Animals which did not die during the 24-hour period after injection usually secreted little or no urine during that time, despite the large volume of fluid (10-30 cc) in which the alginate was administered. When urination recommenced only small amounts of concentrated material were obtained and all contained large amounts of protein, but no reducing substances.

* Same sample as 41-116 used by Frantz 4

Examination of the animals which died spontaneously or were sacrificed following intraperitoneal injection revealed that practically complete absorption of the alginate occurred if the animals survived more than two days. The peritoneum showed no evidence of irritation and was smooth and glistening when absorption was complete. Occasionally small gelatinous flecks of the unabsorbed material could be detected.

Following both intravenous and intraperitoneal administration the abdominal viscera usually appeared normal by gross inspection although occasionally small hemorrhagic areas could be discerned in the bladder wall and kidney cortex. The lungs were occasionally affected, being hemorrhagic to the point of hepatization in four of the animals receiving the larger doses. Upon opening the chambers of the heart massive pale yellow (antemortem or "chicken fat") clots were visible in nearly half of the animals of these groups. The clots were firmly attached to the wall of the chamber and frequently extended through the valves, coalescing with clots in the adjacent chambers. In animals which died later in the course of poisoning some organization of these clots was apparent on microscopic examination. In one animal in which no clots could be found, there were extensive subendocardial hemorrhages in the left ventricular wall. No significant difference in the incidence of these changes between the intravenously and intraperitoneally injected groups could be detected.

Microscopic examination revealed varying degrees of renal tubular damage. In the most severe cases the epithelium of the tubules of the loop of Henle was completely separated from the basement membrane, the nuclei were pyknotic and darkly stained and most of the papillary ducts were occluded with basophilic casts (alginic acid?) containing cell fragments.

The liver frequently contained areas in which the entire cytoarchitecture was disrupted by necrosis and fragmentation of the cells. Other areas were evenly acidophilic and no cell structure could be discerned. No increase of basophilic material which might be interpreted as storage of alginate was found.

Examination of the brain, lungs and adrenals occasionally revealed a thrombosed blood vessel containing hyaline, basophilic material. In the cerebellum degeneration of neurones was noted in discrete areas, suggesting occlusion of the blood supply to such areas.

C TOXICITY OF DI-ALDEHYDE ALGINIC ACID GAUZE (41-151, 152)*

It was reasoned (see also Solandt) that the coagulation noted with alginate was the result of its ability to form firm gels with calcium salts. Oxidizing alginic acid with periodic acid produces a di-aldehyde structure by cleavage of the ring at the 2-3 carbon linkage, resulting in a substance which is actively hemostatic and at the same time does not form a strong gel with calcium salts.

* These compounds were prepared by Dr. James J. Eberl for the purposes of this investigation.

Although gauze prepared from this material required formaldehyde sterilization it appeared feasible to employ it in surgery

As shown in Table V cats were injected intraperitoneally with various doses of this material (41-151) in a 2.6 per cent solution of the sodium salt. These animals followed a course similar to the animals described above. One animal died, although it had received the smallest dose, however, it was in the early stages of pregnancy. The pattern of the course of poisoning in this animal was typical of alginate intoxication, although grossly the post-mortem examination was negative. Only one of the remaining animals failed to show ataxia or depression of the placing reflex. In four, the placing reflexes were

TABLE V — *Toxicity of Di-Aldehyde Alginic Acid*
(Following Single Intraperitoneal Injection)

Experiment Number	Dose mg /kg	Died (D) or Sacrificed (S)	Duration of Experiment	Degree of Effect	Comment
41-151					
26	500	S	8 days	2 +	
27	500	S	10 days	1 +	
37	500	S	8 days	3 +	Antemortem clots
38	500	S	9 days	4 +	" "
39	500	S	9 days	1 +	" "
40	500	S	9 days	3 +	" "
41	500	S	9 days	3 +	
29	250	S	8 days	1-2 +	
28	250	S	8 days	3 +	
30	125	S	7 days	3 +	Falls on walking
31	125	D	5 days	4 +	" " "
					Pregnant
41-152					
25	125	S	12 days	0-1 +	
24	125	S	7	0	
22	250	S	9	1 +	
23	250	S	9	0	
20	500	S	10	0-1 +	Did not eat
21	500	D	4	4 +	Occasional convulsions

absent and ataxia was so severe as to render locomotion nearly impossible, the degree of impairment being apparently independent of the dose. All were depressed, inactive and unaggressive. In these cats the evidence of central nervous system damage persisted until sacrifice, while the other less affected cats recovered rapidly. Some degree of kidney damage was frequent as indicated by the occurrence of proteinuria and hematuria. Urine secretion was suppressed or very slight on the first day after the injection but diuresis subsequently occurred and persisted for a day or two.

Post-mortem examination of the sacrificed animals revealed that practically complete absorption of the solution had occurred, leaving the peritoneum without evidence of irritation. The hearts of five of the cats receiving 500 mg /kg doses contained typical ante-mortem clots varying in size from one millimeter in both dimensions to massive clots several centimeters long and

nearly a centimeter in diameter. Although intracardiac clotting had been anticipated following its occurrence with alginic acid, no signs or symptoms indicative of the phenomenon could be detected prior to death.

Five test animals and one uninjected control were studied for one week before and one week after the intraperitoneal injection of 500 mg/kg of di-aldehyde alginic acid (Table V and Table VI). In view of the observation

TABLE VI—Results of Laboratory Tests on Cats Receiving Single Intraperitoneal Doses of 500 mg/kg of Di-Aldehyde Alginic Acid

Experiment Number	Days	NPN mg%	Sedimentation rate mm/hr	Per Cent RBC	Urine
36	0	47	17.0	38	Negative
	9	47	7.0	40	Negative
37	0	55	0.7		
	7	63	1.0	50	Negative
	11	47.4	17.0	48	4+ protein
	16	45	11.0	41	3+ protein
38	0	41	26.9		Negative
	7	47			
	11	55	63.0	28	3+ protein
	16	44	55.0	30	2+ protein
39	0	45	16.7		
	8	63	8.0	41	
	11	42	53.0	37	3+ protein
	16	47	30.0	39	Negative
40	0	47	7.8		Negative
	7	50	1.0	42	
	11	41	57.0	27	Negative
	16	48	56.0	31	Negative
41	0	52	7.8		
	8	51	0.2	42	
	11	59	24.0	48	3+ protein
	16	66	22.0	40	Negative

of Solandt² that sodium alginate increased the sedimentation rate of erythrocytes the erythrocyte sedimentation rate was determined as well as the per cent erythrocytes. Urine was examined for protein and reducing substances and blood non-protein nitrogen levels were determined. The occurrence of protein in the urine and a marked increase in the sedimentation rate following the injection were the only changes of significance noted. The blood non-protein nitrogen levels were variable, as is so often the case in cats, but were not significantly changed.

Six animals were studied in a similar fashion except that the gauze was shredded and introduced through a small incision into the peritoneal cavity. Doses of 100, 250, and 500 mg/kg were given in this fashion. Although

some depression and occasional vomiting occurred for several days after the operation, there was little evidence of significant central nervous system involvement. Proteinuria and an increased sedimentation rate were observed in all but one animal (100 mg/kg) and persisted for five to ten days. On post-mortem examination the gauze was found to have been well absorbed although the peritoneal cavity usually contained ten to twenty cubic centimeters of pinkish watery fluid, a larger amount than that noted following injection of the dissolved material. No other pathologic changes were observed with the exception of one small ante-mortem clot in the left ventricle of a cat receiving a dose of 250 mg/kg.

A sample (41-152) of similar material was obtained which contained approximately 2 per cent of "Fixanol" (octyl pyridinium bromide), a sizing

TABLE VII—*Toxicity of Decarboxylated, Nitrated Alginate Gauzes (89-31, 32)*
(By Single Injection)

Experiment Number	Dose Mg/kg	Route	Sacrificed (S)	Duration of Experiment	Degree of Effect	Comment
89-31						
50	500	I P	S	4 days	4+	Multiple massive hemorrhages
55	500	I V	D	1 day	4+	
51	250	I P	D	1 day	4+	
56	250	I P	S	5 days	1+	
57	250	I P	D	5 days	4+	
52	100	I P	—	—	0+	Polyuria
89-32						
65	500	I P	D	3 days	4+	Massive hemorrhage
67	500	I P	D	1 day	4+	
66	250	I P	S	5 days	4+	

agent used to prevent the monofilaments of alginic acid from sticking together. In view of the unsatisfactory nature of the unsized preparation (41-151) the sized preparation was examined less thoroughly. One death at a high dose level and three animals typically affected to a lesser degree, were obtained in a series of six cats (Table V). It is improbable that thread sizing decreases the toxicity of alginic acid and it evidently does not increase it.

It is apparent that the reduced gelling capabilities of the di-aldehyde alginate preparation were still sufficient to cause serious vascular occlusion. The modified gauze was readily absorbed but too toxic to be clinically useful.

D THE TOXICITY OF NITRATED SODIUM ALGINATE (89-31, 32)

Cats were injected intraperitoneally with a sodium bicarbonate solution of an alginate gauze prepared by decarboxylating and nitrating alginic acid (see Table I). These experiments are listed in Table VII.

This material was markedly toxic. Vomiting, depression and ataxia were present as previously described, but in addition there developed a hemorrhagic diathesis manifested by bleeding and swollen gums, hemorrhages and hematuria. On post-mortem examination extensive hemorrhages were found in nearly every organ and the blood did not clot within an hour after withdrawal

Urine from these animals reduced Benedict's solution, differing in this respect from the other alginates studied but resembling oxidized oxycellulose (qv) It is apparent that nitration and decarboxylation of alginate do not produce a usable gauze

E COMPARATIVE EXAMINATION OF OXIDIZED CELLULOSE GAUZE

A series of ten cats was studied in which intraperitoneal injections were made of a sodium bicarbonate solution of a sample of oxidized cellulose gauze Following the injection no vomiting occurred No abnormalities of behavior were noted on subsequent days with the exception of the two animals (67, 70) described in Table VIII These had depressed or readily fatigued placing reflexes for a few days, which returned to normal in about a week All cats

TABLE VIII—*Toxicity of Oxidized Cellulose Gauze Following Intraperitoneal Injection of a Sodium Bicarbonate Solution of the Gauze (By Single Injection)*

Experiment Number	Dose Mg /kg	Died (D) or Sacrificed (S)	Duration of Experiment	Degree of Effect	Comment
32	500	S	7 days	0	
34	500	S	6 days	0	
65	500	S	14 days	0	
67	500	S	14 days	0-1	Placing reflexes depressed for 5 days
68	500	S	14 days	0	
33	250	S	13 days	0	
35	250	S	5 days	0	
66	250	S	14 days	0-1	Placing reflexes easily fatigued
69	250	S	14 days	0	
70	250	S	14 days	0	

developed proteinuria one or two days after the injection Within five days this had ceased but during the entire period of the experiment after the administration of oxidized cellulose their urine reduced Benedict's solution Oxidized cellulose itself readily reduces Benedict's solution so that it may be presumed that oxy-cellulose, or portions of its molecule, were excreted in the urine

No animals died nor were any noticeably affected by their experience When sacrificed, post-mortem examination revealed that absorption was complete No gross pathologic changes were noted and there was no evidence of intravascular clotting It is apparent that oxidized cellulose is much less than alginate

DISCUSSION

As the result of this study of the action of alginate gauzes in the animal body the material can not be recommended for surgical use as an absorbable gauze It would seem that the ability of alginate acid to form gels with calcium,^{1, 2} which may or may not be the mechanism underlying its hemostatic action, is sufficient to cause serious localized circulatory embarrassment

Apart from this action, the production of hepatic and renal impairment is a contraindication for its use

The present study largely made use of parenteral injection of solutions of the various alginates and it may be argued that the production of toxic reactions by such means does not form an appropriate basis for clinical evaluation, none the less, intravenous administration of even larger doses of oxidized cellulose has been shown to be innocuous³ This was completely confirmed in the small series of cats presented in the present report

While the experiments in which the shredded, relatively innocuous di-aldehyde alginate acid was introduced into the peritoneal cavity were not attended by evidence of marked toxicity its use has not been very satisfactory in experimental surgery⁴ Although Blaine¹ did not report any toxic effects from the use of alginate materials the present studies indicate that it is not without danger for clinical use

Solandt's² observation that alginate acid increases the sedimentation rate was confirmed It was noted during *in vitro* studies of this phenomenon that the hemoglobin of cells caused to settle in this fashion was not readily oxygenated on agitation This has also been reported for acacia⁵ Although efforts were made to demonstrate a lowered arterial or venous oxygen content such as was reported for acacia no definite conclusions could be drawn from the data It may be inferred that this action of alginate acid is not of major importance as a cause of its toxicity

SUMMARY

- 1 The intraperitoneal or intravenous injection in cats of solutions of sodium alginate results in the production of large ante-mortem intracardiac clots
- 2 Evidence is presented that injury to the brain, liver and kidney frequently occurs Alginate acid shares with other gums the ability to accelerate the sedimentation of erythrocytes
- 3 A di-aldehyde derivative of alginate acid is slightly less toxic than alginate acid while a nitrated derivative is more toxic and in addition greatly prolongs clotting time *in vivo*

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SIGNIFICANT ANATOMIC RELATIONS IN THE SYNDROME OF THE SCALENE MUSCLES

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THE GROUP OF SYMPTOMS commonly referred to as the scalenus anticus syndrome seems more likely to develop in certain persons than in others. Bilateral dissections of the area in question were done on 56 cadavers in an effort to discover significant anatomic relations to explain this fact. Particular attention was directed toward the modifications in structure and anatomic relations of the scalene muscles, the components of the brachial plexus and the adjacent vessels.

It should be recalled that originally this set of symptoms was associated only with the presence of a cervical rib and was designated as the syndrome of the cervical rib. Subsequent investigations further clarified the problem and demonstrated that other factors entered into the production of the syndrome. The syndrome of the cervical rib was described by Murphy¹ as including any or all the following: 1) pressure on the trunks of the brachial plexus with pain, paresthesia, hypesthesia, or anesthesia in the peripheral area of distribution of the involved sensory fibers, and paresis or paralysis of the muscles supplied by the involved motor fibers, 2) pressure on the subclavian artery with brachial ischemia and possible aneurysmal formation, thrombosis and gangrene, and 3) development of a tumor in the supraclavicular triangle. The fact that this syndrome might occur in the absence of a bony anomaly was recognized by Murphy,² who described a case which presented many of the manifestations of the cervical rib syndrome but no cervical rib was present. At operation the lower trunk of the brachial plexus was found on the inferior portion of the anterolateral border of the scalenus medius muscle. The insertion of the muscle at that point was severed and the subjacent portion of the rib resected. There was complete relief of symptoms. Jones³ stated that in some individuals the eighth cervical and first thoracic segments contribute an unusually large proportion of the fibers to the brachial plexus and in these cases the first thoracic rib may traumatize the lower trunk of the plexus. Post-fixation of the brachial plexus was the term applied to those cases in which a comparatively large number of the component fibers emerge through the lower contributing segments. A plexus which received a relatively large number of fibers from the upper contributing segments was termed pre-fixed. Wilson⁴ described two main types of muscular involvement by cervical ribs. One was designated the median type because some or all the

intrinsic muscles of the hand supplied by the median nerves were involved. These patients usually also demonstrated sensory impairment of the lateral portion of the forearm and hand. The other type, stated to be the more common, included those cases exhibiting involvement of the intrinsic hand muscles supplied by the ulnar nerve. Atrophy or weakness of these muscles usually was accompanied by sensory phenomena in the peripheral area supplied by the ulnar nerve. Wilson noted that in several patients hypesthesia or anesthesia was confined to the peripheral area usually assigned to the sixth cervical nerve. He stated that this root is not involved by a cervical rib but attempted to explain the observation by stating that these might also represent cases of post-fixation of the brachial plexus in which the seventh cervical nerve and not the sixth was involved.

Much of the clarification of the cervical rib and scalene syndromes is the result of Todd's work⁵⁻⁹. He accounted for the reportedly higher incidence of these symptoms in females on the basis of muscular development and respiratory activity. He believed that because of the relatively poor development of the trapezius muscle in females, the shoulder would assume a comparatively lower position in relation to the thorax than in males. He also stated that the comparatively poor development of the rectus abdominis muscles of females might allow the skeletal structure of the thorax to adopt a relatively higher position than in males. Todd suggested further that the symptoms might occur more frequently in women because of their greater use of the upper thoracic muscles in respiration. He disagreed with previous statements that the subclavian artery could be compressed by the scalenus anticus muscle or the first rib. He believed that the vascular symptoms in cases of cervical rib syndrome are not mechanical in origin but trophic in character and are caused by involvement of the sympathetic fibers passing across the first rib to enter the lower trunk of the brachial plexus.

The theories of both Jones and Todd were supported by Stopford,¹⁰ who stressed the importance of the first thoracic rib as an etiologic factor in neuritis of the lower trunk of the brachial plexus. He believed, as did Jones, that a predisposing factor is the anatomic relation of the nerve trunk and the rib, when the bone is bevelled by a trunk which received a large contribution from the upper two thoracic roots. He also agreed with Todd that the anatomic changes of the shoulder in relation to the trunk are important factors in the onset of symptoms. It was reiterated that the medial portion of the clavicle may be elevated or depressed depending upon the tonicity and development of the rectus abdominis muscles and that the position of the lateral portion may be similarly changed depending upon the strength and tone of the trapezius muscle. He concluded that these two factors acting on the clavicle are of importance in the production of compression of the lower trunk of the brachial plexus by the first rib and also explain the greater incidence of this syndrome in females.

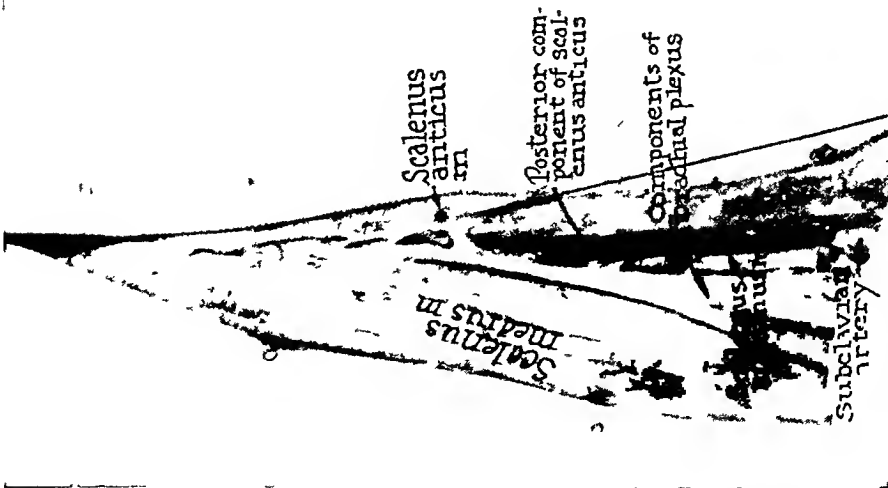


FIG 1—Lateral view of supraclavicular area showing relations of "posterior component" of the scalenus anticus, main body of scalenus anticus, scalenus minimus and medius, brachial plexus and subclavian artery

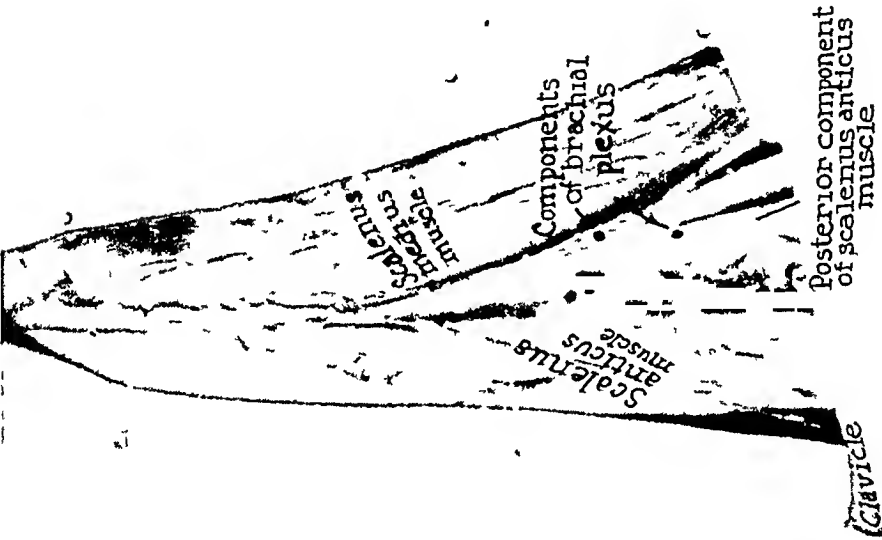


FIG 2—Anterolateral view of supraclavicular area showing relations of "posterior component" of the scalenus anticus to other remainder of the muscle and to the brachial plexus

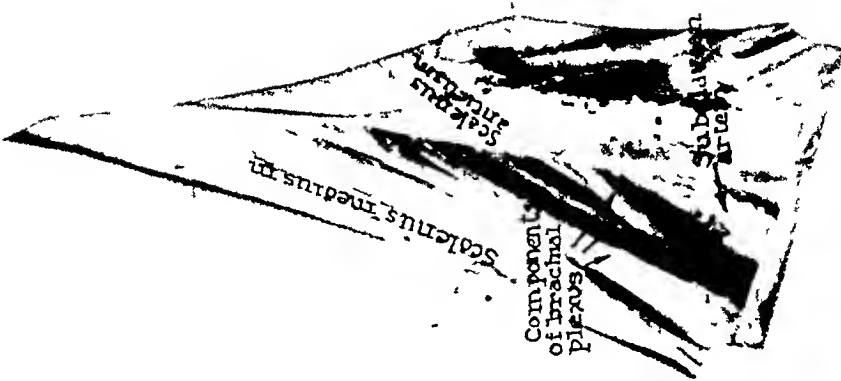


FIG 3—Anterolateral view of supraclavicular area showing relations of brachial plexus, subclavian artery and the scalenus anticus and medius muscles

Buckner and Milch¹¹ similarly reemphasized the significance of the relation of the position of the shoulder to the thorax in the production of the symptoms characteristic of the cervical rib syndrome either in the presence of a cervical rib or with a normal first thoracic rib

Adson and Coffey¹² disagreed with Todd's statement that the contracting scalenus anticus muscle could not compress the subclavian artery. They reported having demonstrated such an action by this muscle by having the patient elevate the chin and extend the neck or rotate the head to the affected side while making a deep inspiration. This resulted in obliteration of the pulse at the wrist on the affected side as well as production of paresthesia in the distribution of the brachial plexus. They advocated that the cervical rib not be removed for the relief of symptoms but that only the scalenus anticus muscle be severed. In their series of cases of cervical ribs 45 per cent exhibited symptoms referable to the anomalous ribs. However, Torelli¹³ reported that only nine of 100 patients with cervical ribs whom he had examined presented evidence that the anomalous rib was causing symptoms. He estimated the incidence of cervical ribs in a large series of cases to be about 2 per cent.

Ochsner, Gage and DeBakey¹⁴ agreed that post-fixation of the brachial plexus or poor development of the elevator muscles of the shoulder or the rectus abdominis muscles may constitute predisposing factors for the development of the scalenus anticus syndrome, but they suggested that spasm of the scalenus anticus muscle resulting from irritation of somatic efferent fibers passing to the muscle in the traumatized brachial plexus caused additional elevation of the first rib with further trauma to the brachial plexus and more muscle spasm. Thus, it was postulated a vicious circle was established which must be broken for relief of the discomfort and could be done so most practically by anterior scalenotomy. They stated that the brachial plexus and subclavian artery are pinched between the scalenus anticus and medius muscles during the phase of muscular spasm. Naffziger and Grant¹⁵ in reporting a series of cases of what was termed scalenus syndrome agreed essentially with previous theories of etiology.

Trauma was believed to have been the precipitating factor in 29 of 115 cases of scalenus anticus syndrome reported by Jelsma¹⁶. Semmes and Murphey¹⁷ discussed the simulation of scalenus anticus syndrome by a herniated sixth cervical intervertebral disk.

Swank and Simeone¹⁸ concluded that the individual portions of the scalenus anticus muscle which arise from the anterior surfaces of the transverse processes of the third, fourth, fifth, and sixth cervical vertebrae can compress the subjacent cervical nerve root as it passes laterally and inferiorly to join the brachial plexus. Primarily on these grounds they explained the various combinations of symptoms which may be seen with spastic scalene muscles.

It should be borne in mind that it has been adequately demonstrated that the same complex of symptoms indicative of trauma to the brachial plexus



FIG 4—Anterolateral view of supraclavicular area showing inferior curved portion of anterolateral border of scalenus medius and its approximation to the scalenus anticus

may be found in the presence of a cervical rib or without an osseous anomaly. In the former case the term, *cervical rib syndrome*, may be used and in the latter the term, *scalenus anticus syndrome*, has been applied. Even though the cervical rib is small, it may be the key to the solution of the patient's difficulty, for sometimes a firm, fibrous cord extends from the tip of the cervical rib to be attached to the first thoracic rib and thus serves as a ridge

SYNDROME OF THE SCALENE MUSCLES

across which the lower trunk of the brachial plexus may be traumatized. However, the anatomic data which we will present indicates that the terms "the syndrome of the scalene muscles" or "the scalene syndrome" are more suitable when there is no roentgenologic evidence of pathologic change. It is evident from this investigation that some term should be used which does not

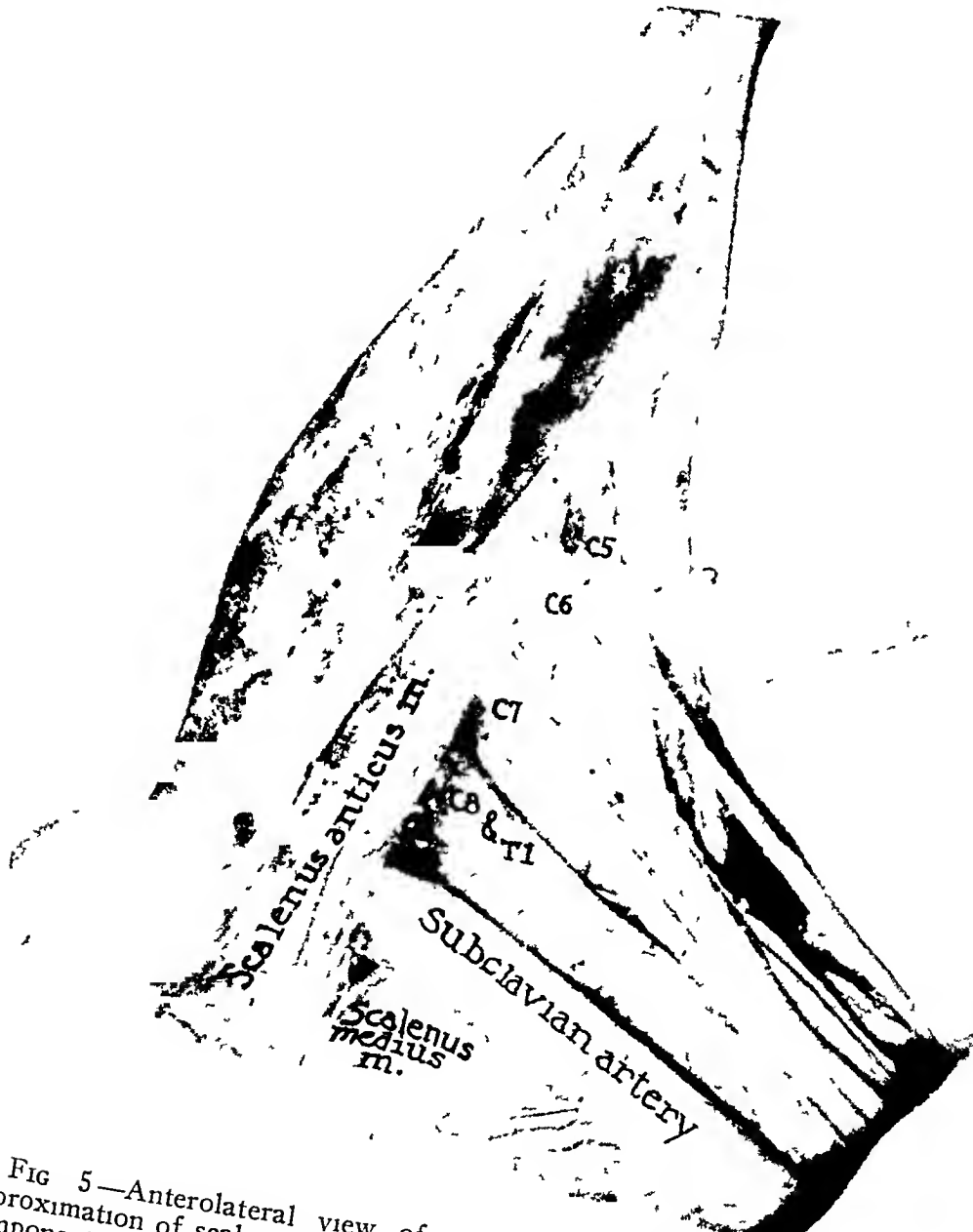


FIG 5—Anterolateral view of supraclavicular area showing close approximation of scalenus medius and anticus and angulation of the lower components of brachial plexus and subclavian artery across anterolateral border of scalenus medius

confine the implication of a pathologic change to the scalenus anticus muscle. It is apparent from a review of the literature that the factors which have been considered of greatest importance in the development of the "scalenus anticus syndrome" include post-fixation of the brachial plexus, an unusually low position of the upper extremity in relation to the thorax, or a relatively

high position of the thorax in relation to the upper extremity, and the state of contraction of the scalenus anticus muscle. Most investigators apparently believe that a combination of all these factors generally is present. The scalenus medius muscle has been given little credit for participating significantly in the production of symptoms. However, Ochsner and associates¹⁴ stated that the brachial plexus may be compressed between the scalenus anticus and medius muscles with increased irritation to the plexus, and Telford

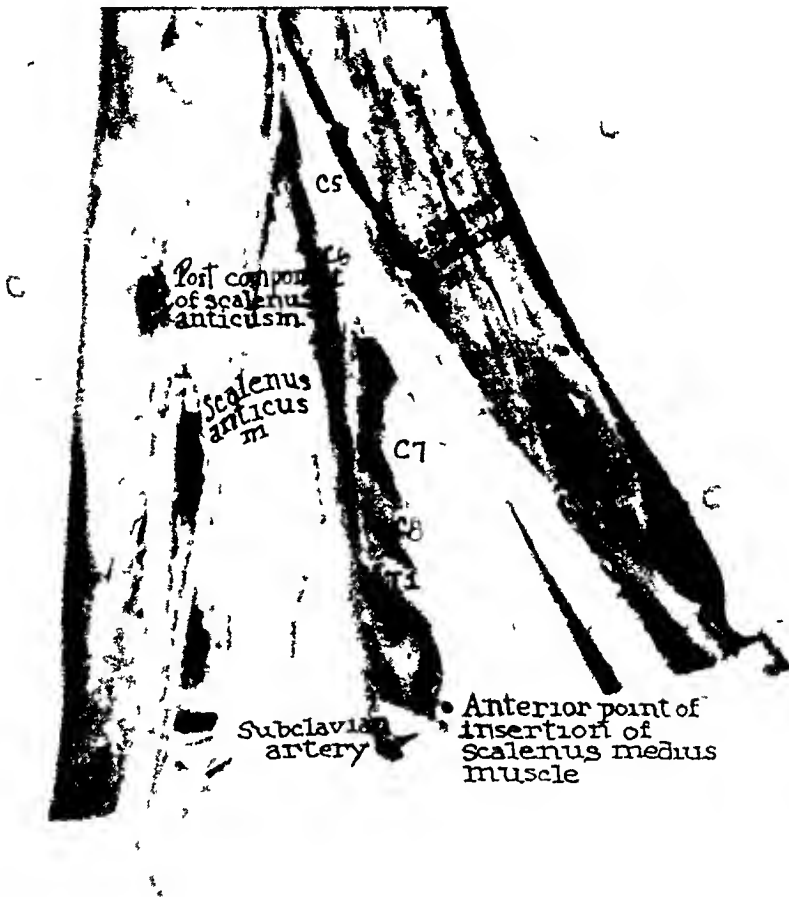


FIG 6—Anterolateral view of supraclavicular area showing usual relation of the anterolateral border of the scalenus medius to the anticus, subclavian artery and brachial plexus

and Mottershead¹⁹ suggested that traction of the brachial plexus across the anterior margin of the scalenus medius muscle may irritate the component nerve fibers. We²⁰ presented evidence before the American Association of Anatomists in April, 1947, that the anatomic relations and the state of contraction of the scalenus medius muscle may be the major factors in the production of the syndrome usually referred to as the scalenus anticus syndrome.

It is of interest to recall that most patients with this syndrome have no bony anatomic anomaly on which to blame the production of symptoms. Moreover, only approximately 10 per cent of individuals with one or more of

the bony anatomic variants frequently associated with this syndrome ever show any of its manifestations. Furthermore, many patients with a herniated cervical intervertebral disk or other lesion causing nerve root irritation exhibit extreme scalene muscle spasm without evidence of any of the described types of scalenus anticus syndrome. Therefore, one would conclude that the syndrome of the scalene muscles is more likely to develop in certain individuals than others for reasons which are not apparent by roentgenographic examination.

The soft tissue structures which have been considered of possible significance in the production of this syndrome and which have been examined in



FIG 7—Anterior view of supraclavicular area showing usual relations of scalenus medius and anticus at their insertions

detail in this group of dissections include the following

1 *Scalenus anticus muscle* In all cases, most of the fibers of this muscle arose from the anterior or inferior surface of the anterior tubercles of the cervical transverse processes from the third to the sixth cervical vertebrae inclusive. These fibers, even if in marked spasm, are not strategically located to compress adjacent roots of the brachial plexus (Figs 1, 2, 3, 9a and 10b). The only possible way for this portion of the muscle to contribute to the syndrome is by elevation of the rib to which it is inserted with consequent trauma to the lower trunk of the brachial plexus. It is possible that such elevation of the first thoracic rib might, in some cases, constrict the lumen of the subclavian artery. The artery may also be compressed by being displaced forward by the scalenus medius against a spastically contracted scalenus anticus muscle (Figs 5 and 10a). However, in most cases muscle fibers arose from the inferior margin of the groove of the transverse process in which each nerve root lay, as well as from the posterior tubercle of the transverse

process (Figs 1, 2, 6, 9b, 11, 12a and b, and 13a and b) and passed inferiorly and anteriorly to join the body of the scalenus anticus muscle and insert with the fibers arising from the anterior surface of the transverse processes. Those fibers having an attachment of origin from the posterior tubercle of the transverse processes have an origin in common with the fibers of the scalenus medius muscle (Figs 1 and 2). These might be termed the "posterior" components of the scalenus anticus muscle. Similar bundles of muscle fibers



FIG 8—Anterolateral view of supraclavicular area showing close approximation of scalenus anticus and medius at their insertions with angulation of subclavian artery and components of brachial plexus across anterolateral border of scalenus medius

SYNDROME OF THE SCALENE MUSCLES

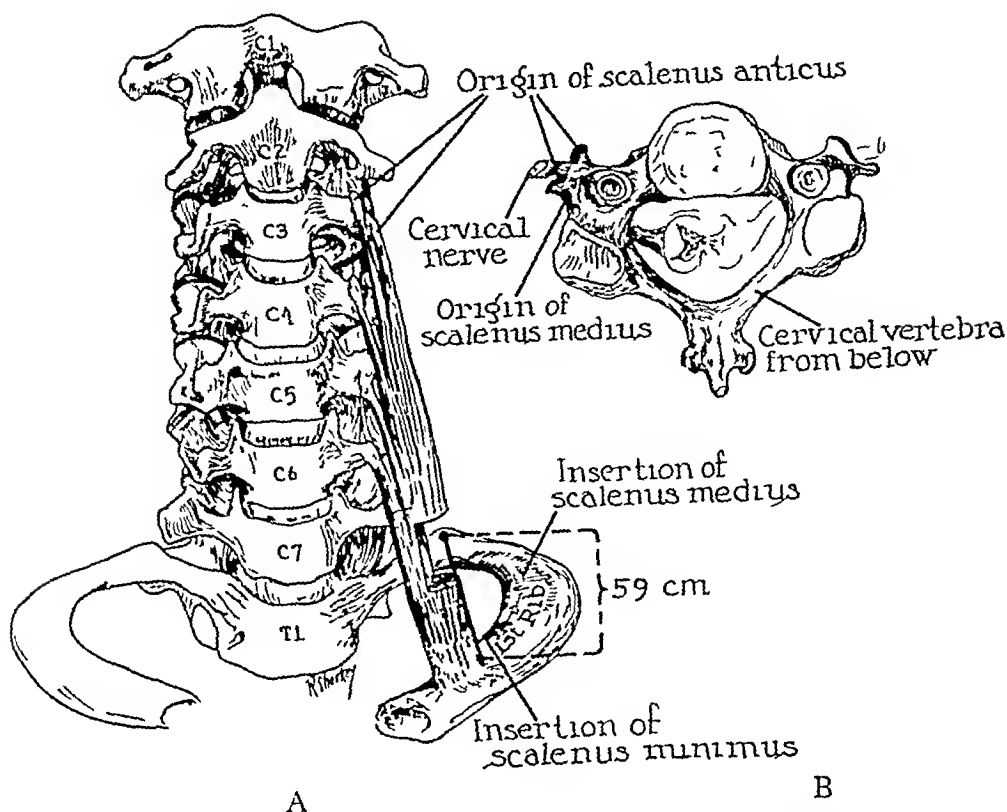


FIG 9—(A) Anterior view of scalenus anticus and related bony structures. Average distance of insertion of scalenus anticus from the tubercle of the rib is indicated as determined on the left in 43 male bodies. (B) Inferior view of cervical vertebra indicating areas of origin of scalenus anticus and medius.

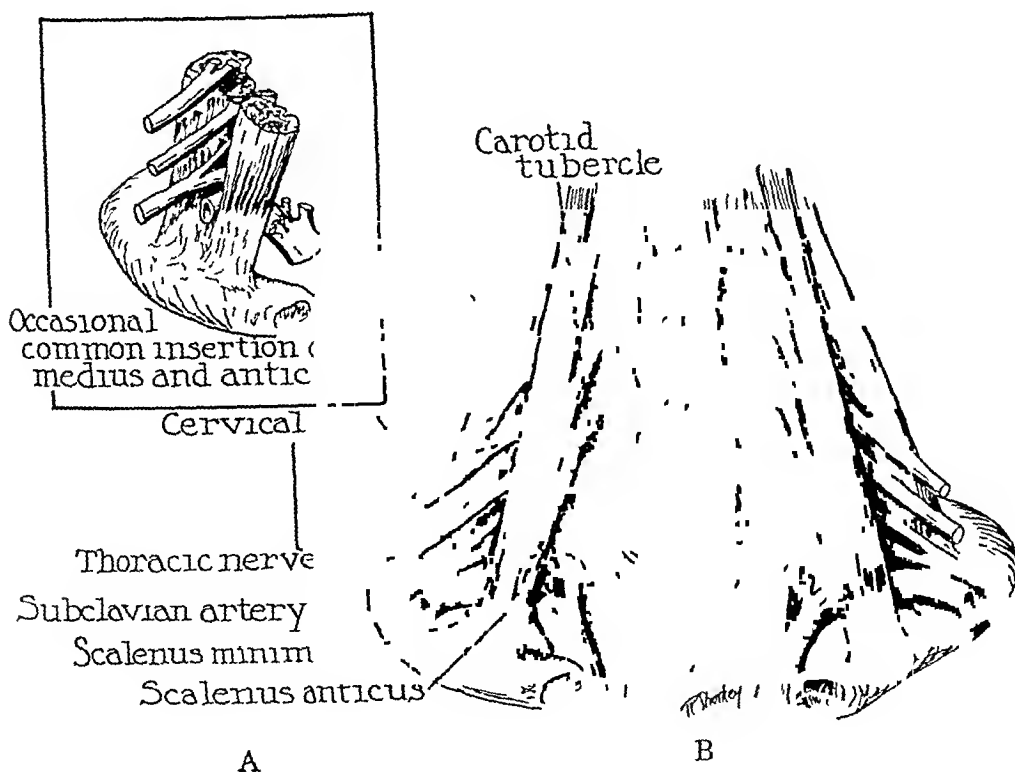


FIG 10—(A) Diagram showing close approximation of scalenus anticus and medius at their insertion. (B) Anterior view of lower cervical and upper thoracic regions showing relations of scalenus anticus, minimus and medius, brachial plexus and subclavian artery.

may have their origins on the tendons which give rise to the scalenus medius muscle. Such bundles of muscle fibers are situated so that upon contracting they might pinch the root of the brachial plexus emerging immediately below them. These groups of muscle fibers are not to be considered anomalous as they were present in most of the bodies studied. However, their size varied considerably as did their relations with the adjacent nerves and the subclavian artery. In the majority of cases the size of these bundles was so small that

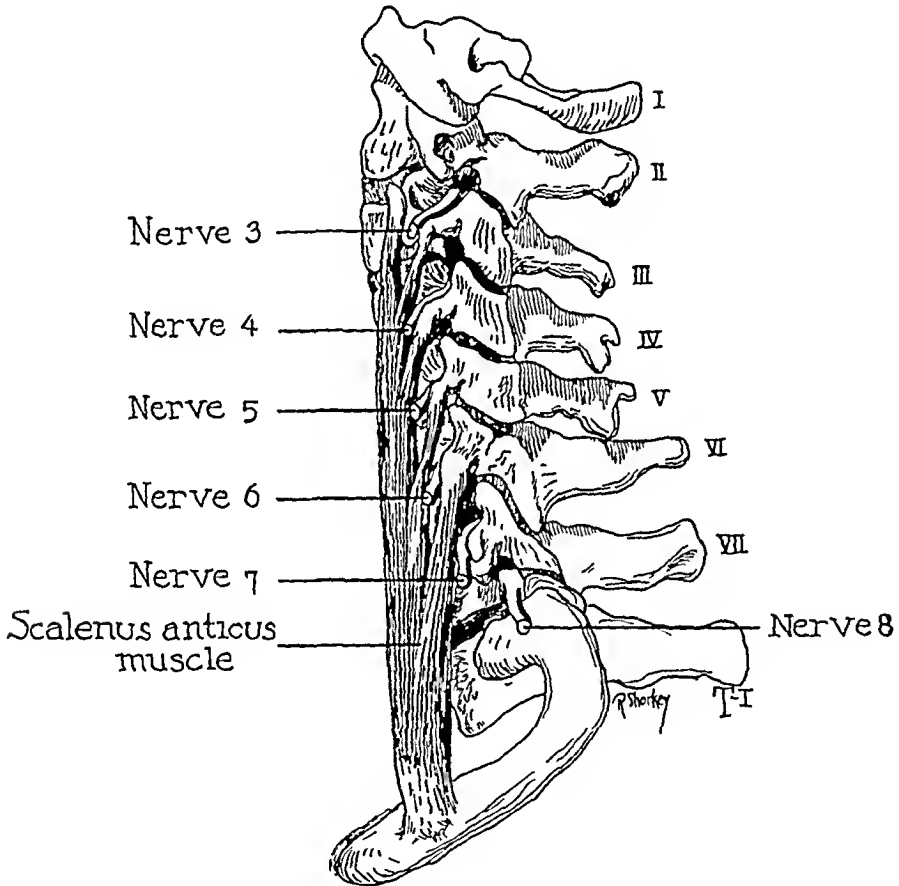


FIG 11—Lateral view of scalenus anticus showing relations of its "posterior components" to the main body of the muscle, to the transverse processes and to the nerves

it was questionable that they would be able to compress the subjacent nerve sufficiently to cause significant irritation of the nerve. The seventh cervical was the nerve most often situated in relation to such a bundle of muscle fibers of apparently significant size (Fig 11). In some instances, muscle fibers arose posterior and inferior to the sixth cervical component to the brachial plexus, passed in front of the seventh cervical component, then posteriorly to descend behind the subclavian artery, and finally anteriorly to insert with the scalenus muscle (Fig 13b). In other cases, muscle fibers with a similar relationship to the seventh cervical nerve inserted with the scalenus minimus or

medius (Figs 12a and b) It is obvious that bundles of muscle fibers which have such a relationship to the seventh cervical nerve, the subclavian artery, and the lower trunk of the brachial plexus might exert undue pressure on these structures. Similar components of the scalenus anticus were commonly present in relation to the fifth and sixth cervical nerves.

A factor in the effectiveness with which the scalenus anticus elevates the first rib is the distance between the insertion of the muscle on the rib and the articulation of the tubercle of the rib. The greater this distance, the more efficiently the muscle can elevate the rib. In 43 male bodies examined this distance averaged 6.0 cm. on the right and 5.9 cm. on the left (Fig 9a). The measurement ranged from 6.4 cm. to 5.2 cm. on the right and from 6.8 cm. to 4.9 cm. on the left. In 13 female bodies examined this distance averaged

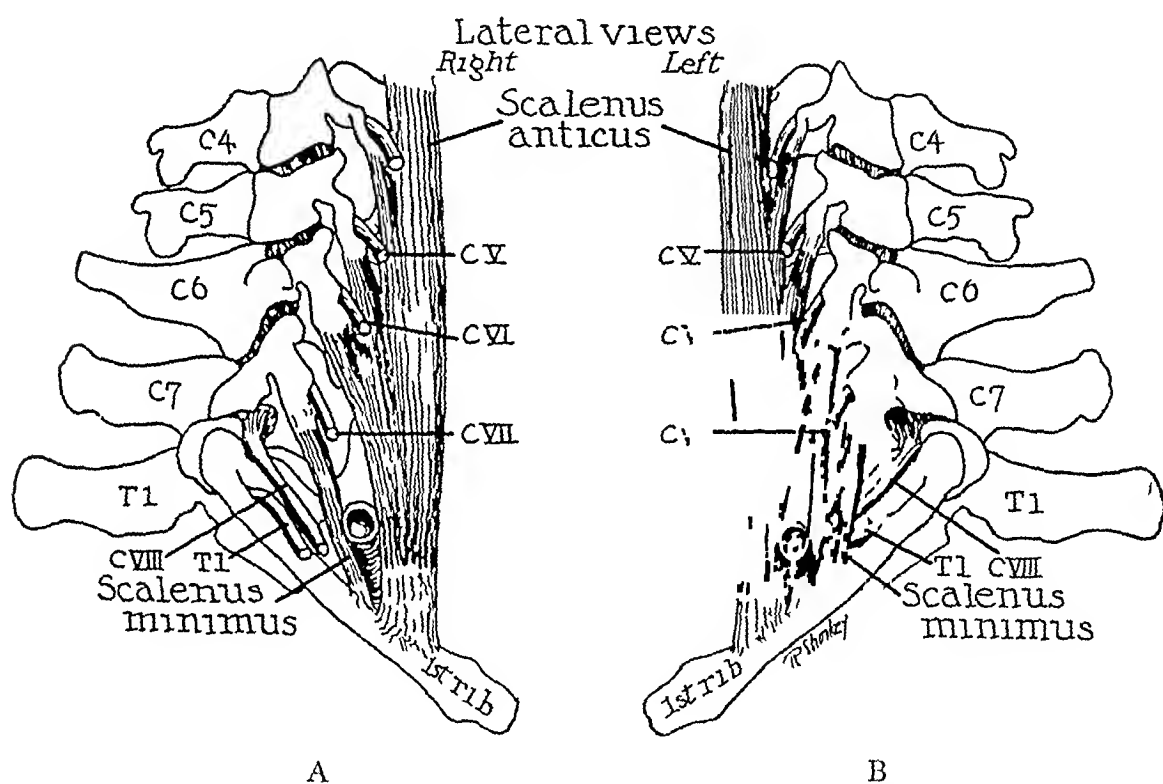


Fig 12—(A and B) Lateral view of scalenus anticus and minimus showing unusual relations to lower components of brachial plexus and to the subclavian artery

5.8 cm. on the right and 6.0 cm. on the left. On the right the distance ranged from 6.6 cm. to 5.0 cm. and on the left from 6.6 cm. to 5.3 cm.

The shorter this distance, the more intimately the muscle is related to the subclavian artery. However, in no instance was it apparent that the bulk of the muscle, that is, the portion arising from the anterior tubercles of the cervical transverse processes, was situated so that it might, by itself, compress the subclavian artery regardless of the degree of spasm. On the other hand, it seems reasonable to believe that the muscle might elevate the first rib sufficiently to compress the artery (Figs 4, 5, 6, and 7). Even in the cases in which the attachments to the first rib of the scalenus anticus and scalenus medius muscles were approximated it was evident that neither the subclavian

artery nor the trunks of the brachial plexus could be compressed directly by the main body of the scalenus anticus muscle acting alone

2 Scalenus minimus muscle This muscle was present on the right in 55.4 per cent and on the left in 56.1 per cent of the dissections. In the majority of instances it was found to arise only from the seventh cervical transverse process (Fig 12a). Occasionally, additional fibers originated from the sixth cervical transverse process (Figs 13a and b). The muscle extends inferiorly and laterally to insert on the first rib usually at a point posterior and somewhat lateral to the attachment of the scalenus anticus muscle (Figs 14b and 15b). In some bodies the width of the insertion of the scalenus minimus was equal to the distance between the attachments of the scalenus anticus and medius. Rarely did its insertion overlap those of the scalenus anticus and medius. In practically all cases the muscle passed behind the subclavian artery and anterior to the lower roots of the brachial plexus from an origin on the seventh cervical transverse process behind the emerging seventh cervical nerve. Usually the relationships and the size of the muscle were such that it did not appear capable of contributing significantly to the complex of symptoms. Just as in the case of the main body of the scalenus anticus, the minimus normally upon contracting would contribute to the symptoms only in so far as it might assist in elevating the first rib. Its location and size are not suitable for the muscle to assist greatly in this activity. However, if the muscle is comparatively large and has a wide insertion extending close to or overlapping that of the scalenus medius, it is strategically situated to function as one of the jaws of a vise in which the eighth cervical and first thoracic nerves may be trapped (Figs 15a and 15b). The opposing jaw of the vise would be the scalenus medius muscle.

Infrequently, the fibers of the scalenus minimus had a complex relation to adjacent structures. For example, fibers sometimes arose from the posterior margin of the sixth cervical transverse process and descended anterior to the seventh cervical nerve, but inserted behind the subclavian artery or even posterior to the eighth cervical and first thoracic nerves (Fig 12b). Such a relationship would allow the spastically contracted muscle to have a maximum of leverage upon the adjacent nerves and artery.

3 Vertebrocostal ligament This ligament occupied the characteristic position of the scalenus minimus muscle bilaterally in 10.7 per cent and unilaterally in 3.5 per cent of the dissections. The attachments were found to be similar. In an analysis of the activity of this ligament in the production of symptoms of the syndrome of the scalene muscles, it should be pointed out that the ligament becomes relaxed as the rib is elevated. Thus, it might act less effectively than the scalenus minimus muscle as one of the jaws of a vise in which the lower roots of the brachial plexus might be pinched. The situation in which it would carry out such a function most efficiently is one in which the scalenus medius contracts sufficiently to displace the first thoracic and eighth cervical nerves but not enough to elevate the first rib.

4 *Scalenus medius muscle* The sites of origin included the posterior tubercles of the transverse processes of the cervical vertebrae from the third to the seventh inclusive. The body of the muscle lay posterior to the roots and trunks of the brachial plexus in all dissections (Figs 1, 5, 6, and 10b). Its usual insertion was to the superficial surface of the first rib from near the tubercle of the rib to within a short distance of the attachment of the scalenus anticus (Fig 14b). The average length of the interval between the insertions of the scalenus anticus and medius muscles in 43 male bodies dissected was 77 mm on the right and 78 mm on the left. In 5 cases, the neighboring borders of the scalenus anticus and medius muscles were contiguous or overlapped. The length of this interval varied up to 18 mm on the right and 19 mm on the left. In 13 female bodies dissected the same interval averaged

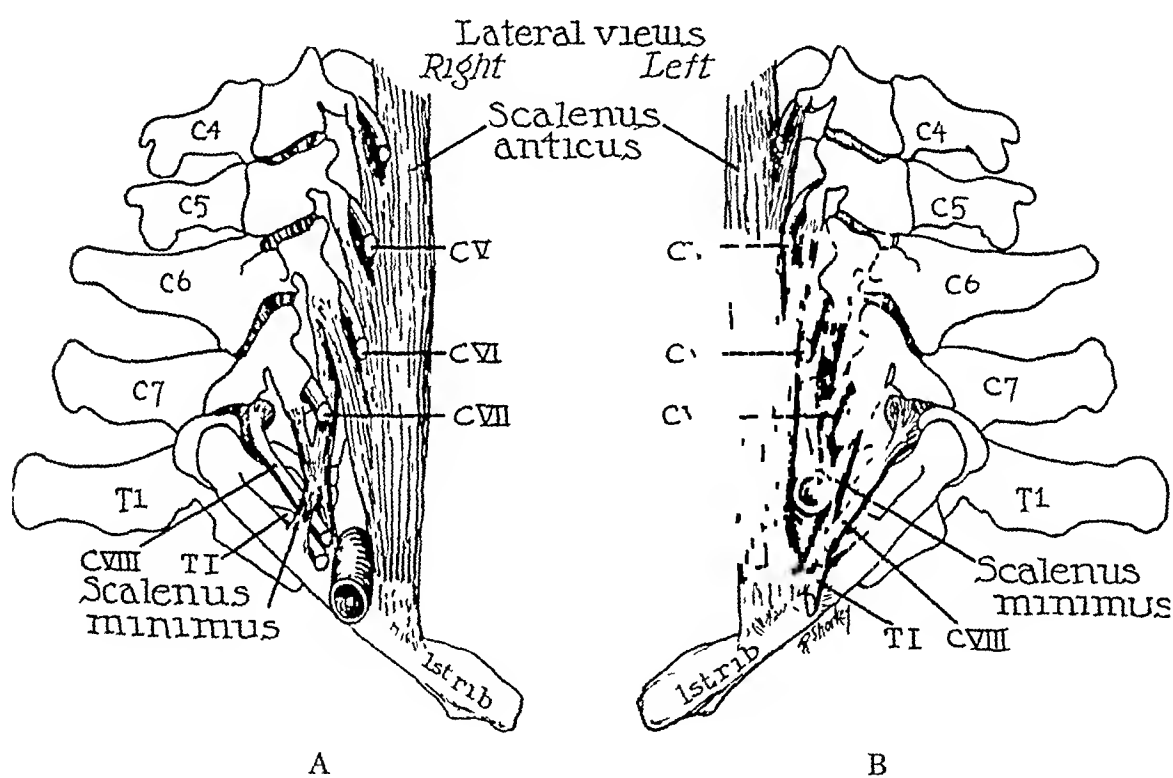


FIG 13—(A) Usual relations of scalenus minimus to anticus, adjacent spinal nerves, subclavian artery and first rib (B) Unusual relations of scalenus anticus and minimus to lower components of brachial plexus and to subclavian artery

66 mm on the right, with a maximum of 13 mm. The average on the left was 65 mm with a maximum of 12 mm. One body revealed an approximation of the adjacent borders of the scalenus medius and anticus.

Although the distance between the insertions of the scalenus anticus and medius muscles, as a rule, was approximately equal on the two sides, in one case there was a 10 mm difference. The variable relationship between the insertions of the scalenus anticus and medius muscles is demonstrated in Figures 4, 5, 6, and 8. The relationship most commonly seen is that shown in Figure 6. Here a distance of 8 mm separated neighboring margins of the scalenus anticus and medius muscles. Figures 5 and 8 illustrate scalenus

medius muscles more strategically located to produce symptoms referable to the brachial plexus

The effectiveness with which the scalenus medius muscle functions in raising the rib is to a large extent dependent on the size of the muscle and the distance of its insertion from the point about which the rib rotates as it is raised. To estimate the variations in this function of the muscle, measurements were made of the distance between the articulation of the tubercle of the first rib with the first thoracic transverse process and the anterior extent of the insertion of the muscle. In the 43 male bodies dissected the distance varied from 6.7 to 3.4 cm. with an average of 4.9 cm. on the right and from 6.8 to 3.2 cm. with an average of 4.9 cm. on the left (Fig. 14a). In the 13 female bodies dissected the same measurement averaged 4.7 cm. on the right and 4.5 cm. on the left. In this group, the distance ranged from 6.1 to 3.5 cm. on the right and from 5.9 to 3.2 cm. on the left.

The distance between the point of emergence of the first thoracic nerve from the intervertebral foramen and the point at which it crosses the scalenus medius muscle is an index of the amount of traction which may be exerted upon the nerve with contraction of the muscle. This distance was established approximately by measuring the interval between the head of the second rib and the anterior point of attachment of the scalenus medius to the first rib. In the 43 male bodies dissected the distance averaged 4.0 cm. on each side (Fig. 14a). This interval ranged, on the right, from 2.5 cm. to 5.2 cm. and on the left from 2.7 cm. to 6.2 cm. In the 13 female bodies dissected, this distance averaged 3.5 cm. on each side. It varied, on the right, from 2.5 cm. to 5 cm. and on the left from 2.7 cm. to 3.8 cm.

In practically all dissections, the lower trunk of the brachial plexus rested on the inferior portion of the anterolateral margin of the scalenus medius muscle as it descended into the upper extremity regardless of the relation between the attachments to the first rib of the scalenus anticus and medius (Figs. 4, 5, 6, 7, 8, and 15a and b). In those bodies in which the distance between the articulation of the tubercle of the first rib with the transverse process and the anterolateral margin of the scalenus medius muscle and the distance between the latter point and the head of the second rib are relatively great, the situation is optimal for irritation to the brachial plexus with spastic contraction of the scalenus medius muscle (Fig. 5). In this instance the former measurement was 6.4 cm. and the latter 5.8 cm. Analysis of our data reveals that such a relationship of the scalenus medius is indicated by approximation or overlapping of the adjacent margins of the scalenus anticus and medius muscles (Figs. 4, 5, and 10a). The anterolateral border of the spastically contracted scalenus medius muscle may act as a sharp ridge over which the component roots of the brachial plexus, especially the seventh and eighth cervical and the first thoracic roots are drawn by the normal activity of the upper extremity. The angulation of these nerves over the anterolateral border of the scalenus medius muscle is accentuated by retraction of the

upper extremities such as in carrying a pack on the back. With contraction of the scalenus medius, the lower trunk of the brachial plexus may be transferred to a location in more direct contact with the first rib. This position is made more traumatic to the nerves because of the elevation of the rib by the activity of both the scalenus medius and anticus muscles. It should be particularly emphasized that the lower portion of the anterolateral margin of the scalenus medius frequently presents a marked concavity in which the lower trunk of the brachial plexus lies. This is well illustrated in Figure 4. Such a relationship allows for maximal displacement of the lower trunk of

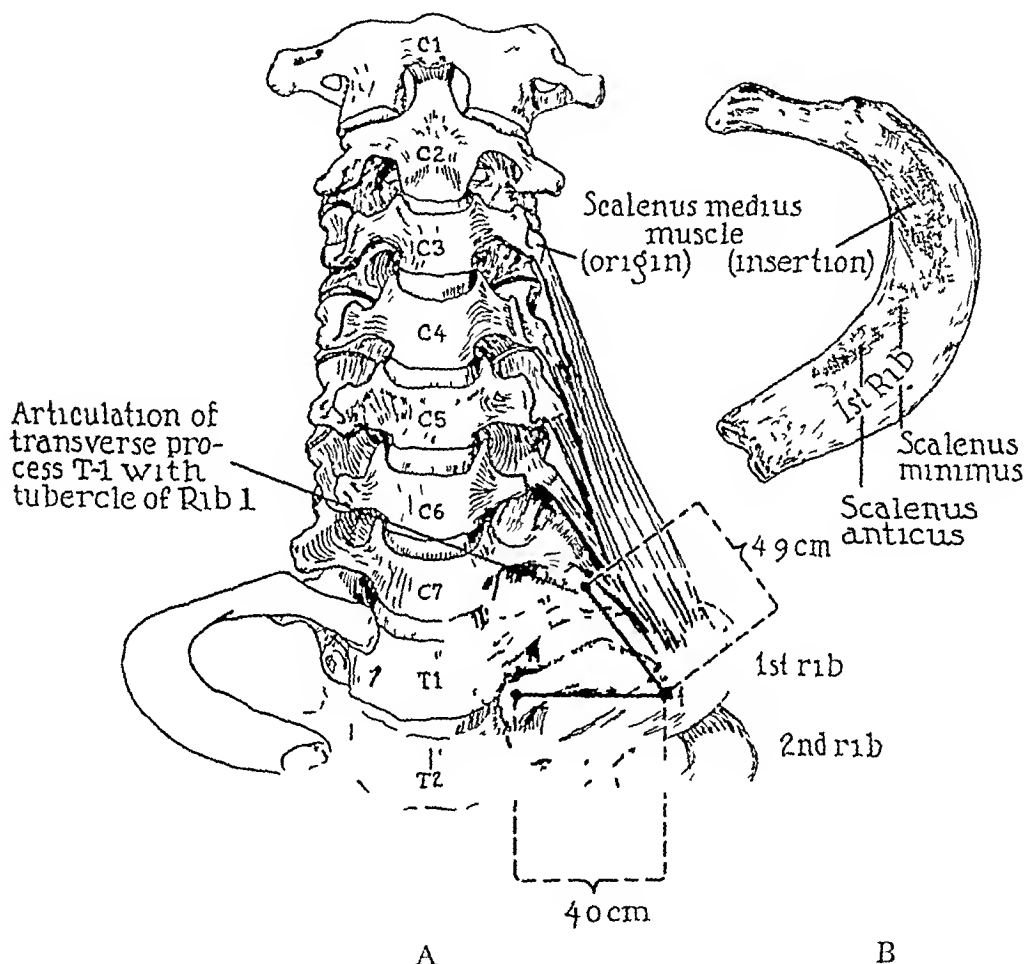


FIG 14—(A) Anterior view of scalenus medius and related bony structures. Average distance of the most anterior point of insertion of scalenus medius from the tubercle of the first rib and the head of the second rib as determined in 43 male bodies is indicated. (B) Superior surface of first rib showing usual relations of insertions of scalenus anticus, minimus and medius.

the brachial plexus from its usual position with spastic contraction of the scalenus medius muscle. The scalenus medius does not have as great a mechanical advantage as the scalenus anticus in raising the first rib because of its being attached to the rib closer to the point about which the rib rotates as it is elevated. However, the proximity of the attachment of the scalenus medius to the articulation of the tubercle of the rib with the vertebra allows it to cause a greater upward excursion of the rib as compared with the range

of movement of the rib caused by a contraction of equal strength by the scalenus anticus. The greater size of the scalenus medius suggests that it may be a more important factor in raising the rib than the scalenus anticus. It should also be noted that the scalenus medius usually has an extensive attachment to a cervical rib when the latter is present and frequently the scalenus anticus has none.

5 *Components of brachial plexus* Although the structure of the brachial plexus varies, it has not been apparent in this series of dissections that the size of the roots of the plexus or their relations with nerves of adjacent segments varied sufficiently to justify the significance which has been attached

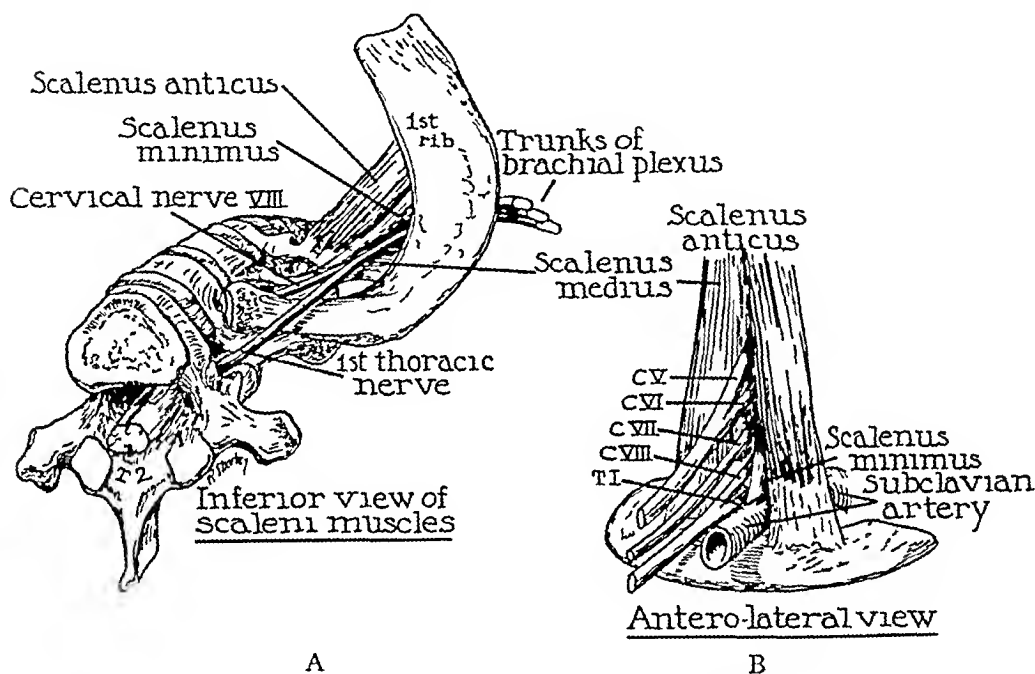


FIG 15—Inferior view of scalenus anticus, minimus and medius showing relations of the eighth cervical and first thoracic nerves. (B) Anterolateral view of supraclavicular area showing usual relations of scalenus anticus, minimus and medius to each other and to the adjacent nerves and the subclavian artery.

to "prefixed" and "postfixed" plexuses. The addition to the upper or lower components of a considerable number of fibers would result in a very small increase in the caliber of the roots. The variation in contributions of fibers from segments above or below the fifth cervical or first thoracic was not found to produce relations of apparent importance.

CONCLUSIONS

This series of dissections has demonstrated several factors which seem of importance in the production of the syndrome of the scalene muscles. These are: 1) elevation of the first rib by the activity of the scalenus anticus and medius muscles aided by the scalenus minimus muscle, when the latter is present, with irritation to the lower components of the brachial plexus, 2) contraction of the "posterior" components of the scalenus anticus muscle with

compression of the immediately adjacent nerve root or the subclavian artery, and 3) traction of the components of the brachial plexus, especially the seventh and eighth cervical and first thoracic nerves, across the anterolateral margin of a spastic scalenus medius muscle. A lesser factor is the trauma which may result from the scalenus minimus muscle or vertebrocostal ligament functioning as the anterior jaw of a vise in which the lower trunk of the brachial plexus may be trapped.

It is impossible for the main body of the scalenus anticus muscle, that is, that portion arising from the anterior surfaces of the cervical transverse processes, to compress directly the components of the brachial plexus. This part of the muscle is important in the syndrome only through its activity in elevating the first rib and in serving as a rigid structure against which the displaced subclavian artery may be compressed. However, direct compression of the fifth, sixth, and seventh cervical nerves, especially the latter two, may result from contraction of the bundles of muscle fibers which arise from the inferior and posterior aspects of the cervical transverse processes and join the main body of the scalenus anticus muscle. Although the presence of such bundles of muscle fibers is common, their size and relation to the adjacent nerve and to the subclavian artery are variable. In those cases in which the relation of the bundle of muscles to the nerve is such that the leverage exerted by the muscle is optimal, it is obvious that even a small bundle of muscle fibers might cause sufficient local ischemia of the nerve to produce symptoms.

An unusually large scalenus medius muscle not only may elevate the rib to a greater degree but forms a more prominent ridge across which the lower components of the brachial plexus may be drawn when the muscle is in spasm. The degree of traction exerted on the components of the plexus is also related directly to the distance which this muscle extends anteriorly along the first rib. If the insertion of the scalenus medius approximates that of the scalenus anticus muscle, the situation is most favorable for the scalenus medius to cause symptoms. Traction of the artery across the edge of the muscle or across the first rib may cause alterations in the volume of the pulse as measured at the wrist.

It is possible that the upper extremity may assume a relatively low position and the thoracic cage a relatively high position because of atony or poor development of the muscles of the shoulder girdle and abdomen. However, it seems doubtful that this relationship is ever changed sufficiently by such phenomena that the lower trunk of the plexus would be irritated by being drawn across the first rib or an atonic scalenus medius muscle. It is apparent, on the other hand, that the presence of such a set of circumstances would make one more susceptible to the development of symptoms indicative of trauma to some or all components of the brachial plexus if the scalene muscles were spastically contracted.

We wish to minimize the probability that pure anatomic relations frequently by themselves initiate such muscle spasm. Instead, we desire to stress that the presence of certain anatomic relationships mentioned in this paper may make one considerably more susceptible to the development of symptoms in the presence of scalene muscle spasm. Anterior scalenotomy possibly too frequently has constituted the treatment of only one of the manifestations of a more serious disease.

We believe that surgical treatment of the syndrome of the scalene muscles should include resection of the major portion of the scalenus anticus and of the scalenus minimus or vertebrocostal ligament when either of the latter is present. In addition, if it is apparent that the lower trunks of the brachial plexus may be traumatized by angulation across the anterolateral border of the scalenus medius, as is suggested by the approximation of its insertion to that of the scalenus anticus, the portion of the scalenus medius immediately posterior to the lower trunks of the plexus should be resected.

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THE LOCAL INJECTION OF PENICILLIN IN ACUTE CIRCUMSCRIBED INFECTIONS

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DIRECT LOCAL INJECTION OF PENICILLIN is an effective and economical method of administering this therapeutic agent in acute localized infections caused by organisms sensitive to this antibiotic. To date penicillin has proved to be the most effective agent against staphylococcic and streptococcic infections. It may be given intravenously, intramuscularly, applied topically, or injected directly into an infected area. The regional injection of penicillin in acute local infections is not new. Florey,¹ Cutler,² Rose and Hurwitz,³ Peck,⁴ Sophian,⁵ Fisher,⁶ and others have employed this technic with excellent results.

The purpose of this report is to record the observations and results obtained by the regional injection of penicillin in over three hundred cases of acute localized infections in various parts of the body. This work was initiated in 1943 on a septic surgical ward of an Army regional hospital, and continued on the surgical out-patient services of Touro Infirmary and of Charity Hospital of Louisiana at New Orleans. The results obtained were so highly satisfactory that it is surprising that this method of administration has not gained in popularity.

Acute infections may be divided for practical purposes into two clinical types.⁷ (1) acute infections which do not cause death of tissue, such as septicemia and cellulitis and (2) acute infections causing suppuration and death of tissue, as seen in boils and carbuncles. In the absence of suppuration or death of tissue, acute infections are superficial and spread over a wide area, relatively unconfined by a wall of inflammatory tissue. In contrast, where suppuration and death of tissue have occurred, a localized area of gangrene is surrounded by a zone of granulation tissue which separates the living from the dead tissue and which circumscribes the infection and prevents its spread, but which also acts as a barrier to a free circulation into the diseased area. Because of these differences, the response to any form of therapy is not the same in these two types of acute infection.

It has been shown that the results of parenteral therapy with penicillin may vary considerably in the two types of acute infection. The results in acute infections in which there is no death of tissue are quite dramatic, while in acute localized infections, with suppuration, the results are not only less dramatic but at times even discouraging. If penicillin therapy is to be effective, the infecting organisms must be susceptible to the antibiotic and an adequate

concentration of the drug must be obtained in the tissue in which the bacteria are imbedded. Because of the impenetrable inflammatory barrier surrounding a localized area of gangrene, circulation to this area is impaired and penicillin, when given parenterally, does not reach the diseased areas in sufficient concentration to be of any value.

Penicillin has several properties that give it distinct value as an antibacterial agent, for local application. It is active against most of the organisms responsible for acute local infections. It is active in high dilutions. It is not inhibited by exudates, and it is non-toxic when given either locally or parenterally.

In view of these facts, it seemed to us that the most suitable method of administration of penicillin in acute localized infections should be direct injection into the infected area. By this means a high concentration and a deep even distribution of the drug at the point where it was needed could be assured. The injections should be repeated often enough to ensure prolonged contact, thereby killing or inhibiting the growth of bacteria, so that the natural defenses of the body could complete the rest of the destruction and proceed with the process of repair.

The response obtained by this method of treatment, when compared with results of the general administration of penicillin, was so striking that it seems worthwhile to direct further attention to this method of treatment.

METHOD OF TREATMENT

Three cubic centimeters of distilled water are injected into the bottle containing 100,000 units of penicillin, making a dilution of approximately 33,000 units to the cubic centimeter. The size of the lesion determines the amount of the solution to be injected. Too much tension in the infected area may break down the barriers that the body has set up to localize the infection and must be avoided. This is a matter of judgment. Small lesions require 0.5 to 1 cc at each injection, while larger ones, such as a carbuncle, may require 4 cc, or even more. Approximately 1 cc is given for the average localized abscess. The required amount is aspirated from the bottle containing the solution and the remainder kept in the ice box for injection on the following day, as the potency of refrigerated penicillin in solution is maintained for approximately twenty-four hours.

The injection is made with a 24-gauge hypodermic needle into the most dependent area of the abscess. Without entirely removing the needle, the operator makes several injections into different areas of the lesion in order to insure an even distribution of the drug. Usually spontaneous evacuation of pus occurs during the injection, depending upon the stage of the infection. If the abscess is superficial and pointing, this occurs practically all the time. In cases in which the abscesses are fluctuant, they are aspirated with a larger needle immediately before the injection of the penicillin solution. In carbuncles the injections are made between the areas of pointing, and the needle is usually inserted deeper than in the localized abscesses.

Following the injection a dry sterile dressing is applied. For several reasons it is desirable to keep the infected area closed: (1) This keeps the penicillin solution in contact with the infecting organisms. (2) It is important to obtain as high a concentration as possible in the diseased area, for in the early stages of infection there are some strains of staphylococci which are resistant to low concentrations of penicillin but are susceptible to the higher concentrations. (3) The danger of infection of the wound by secondary invaders which may produce penicillinase is minimized.

The injections are usually quite painful, the degree of pain varying with the density of the tissues and the volume of the fluid injected. However, the pain does not persist more than 4 to 6 hours.

Some increased redness is usually noted on the day following the injection. At that time another injection is made in the same manner as the first. On the third day the degree of resolution noted is quite surprising.

In about one-fifth of the furuncles only one injection was necessary, the others required 2. Most were entirely healed on the fourth day. The carbuncles required 3, and occasionally 4, injections, and were healed on the tenth day. In a large number of abscesses there was complete absorption without any external drainage.

RESULTS

Carbuncles—There were 24 carbuncles in this series: 8 on the posterior aspect of the neck, 10 on the upper back, 2 on the buttocks, 1 on the right anterior lateral abdominal wall, and 3 on the thigh. The average number of injections given on successive days was 3. The average number of days required for healing was ten.

These results are in marked contrast to those observed following surgical procedures. An average of 43 days was required for healing following incision and drainage in a series recently operated by Maes and Herringman^{8,9}. Extremely gratifying, in addition to the rapid healing time, was the cosmetic result obtained. There was no loss of skin and there were no deforming scars, as seen following surgical intervention.

A short control series was run in this group. Two patients with carbuncles on the neck were given 30,000 units of penicillin parenterally every three hours for seven days. At the end of this period both patients still had large carbuncles with many areas of drainage. It was six weeks following incision and drainage before healing took place. Two carbuncles on the back of the neck were injected locally with 100,000 units of penicillin in 3 cc of distilled water daily for three days. In addition, 30,000 units of penicillin were administered intramuscularly every three hours for ten days. The response was dramatic. The carbuncles seemed fairly to melt away and were entirely healed in ten days. Two carbuncles, one on the back of the neck, the other on the buttocks, were treated solely by local injection of 100,000 units of penicillin in 3 cc of distilled water daily for three days. The results were equally as good as in the group which had been given penicillin parenterally as well as locally.

In the two patients who received penicillin parenterally only, it is doubtful that the drug reach the infected areas in sufficient concentration to be of any definite value. Because of the inflammatory barriers surrounding the infection and the lack of circulation to the necrotic center, the antibiotic could not be expected to reach the bacteria imbedded in the slough and sterilize it. In contrast to the difficulty and expense of the maintenance of a high concentration of penicillin by parenteral administration over a period of many days or weeks, local injections offer a suitable and efficient alternative.

Furuncles—Furuncles formed the largest group in this series of cases. Eighty-seven per cent responded favorably to this form of therapy, 13 per cent required incision and drainage.

Breast Abscesses—Two abscesses of the breast were seen. They were both superficial, located near the nipple, and fluctuant. They were aspirated and injected with 60,000 units of penicillin in 2 cc of distilled water on two successive days. Both were healed on the fifth day.

Axillary Furunculosis—There were 10 cases of axillary furunculosis. Seven patients had multiple lesions. All responded favorably and there were no recurrent "crops" as often seen following incision and drainage. The average time for healing, following 2 successive injections, was five days.

Cellulitis—While a fairly large number of cellulitides were seen, only a few were treated by local injections and this procedure was soon discontinued. These infections are superficial and not well localized. Any increased tension in them will cause the infection to spread. This happened in one of our patients when we first began this form of therapy. A young man was seen with an area of cellulitis measuring approximately 5 x 6 cm on the ventral aspect of the right upper forearm. The area was injected locally with 60,000 units of penicillin in 2 cc of distilled water. The following day the area of inflammation had spread to an alarming proportion. He was admitted to the hospital and, with the administration of penicillin intramuscularly, the lesion cleared in a short time. This type of infection responds rapidly to parenteral therapy and should be so treated.

CONTRAINDICATIONS

Local injection of penicillin is not recommended in infections in the dangerous areas of the face, in cellulitides, and in bone felons.

COMMENT

It is not the purpose of this report to leave the impression that this form of therapy should be used in all types of acute localized infections. It should be reserved for the more serious ones and for the lesions so located that surgical procedures may produce a bad cosmetic result. It is useful when surgical intervention has proved to be inadequate. In well localized infections that are fluctuant, simple aspiration or incision and drainage are the procedures of choice. Surgical judgment should be exercised in each individual case.

SUMMARY

(1) The technic and the results of the local injection of penicillin in acute circumscribed areas of infection in over three hundred ambulatory patients are presented

(2) Experience with this method of local therapy with penicillin has demonstrated that it is safe, effective and economical. There were no complications.

(3) Because of the impermeable inflammatory barrier surrounding an acute localized infection, penicillin, when given parenterally, may not reach a sufficient concentration in the affected area for therapeutic effectiveness.

(4) By local injection it is possible to reach a concentration in the infected area far in excess of the highest levels obtained by intramuscular administration.

(5) Following injection directly into the affected tissue, there is almost immediate improvement and recovery is established in a few days.

(6) Extremely gratifying, in addition to the rapid healing time, is the cosmetic result obtained. There is practically no loss of skin and no deforming scars are seen as usually found following surgical intervention.

(7) This procedure is not recommended for the treatment of the cellulitides, for infections in the dangerous areas of the face, or for bone felons.

(8) Surgical judgment must be exercised in each individual case.

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TEMPORARY FAILURE OF GALLBLADDER VISUALIZATION BY CHOLECYSTOGRAPHY IN ACUTE PANCREATITIS

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DURING A FIVE-YEAR PERIOD intravenous cholecystograms were done on 28 patients with acute pancreatitis. In all cases the initial cholecystography was performed during the acute phase of the disease (Table I). In 12 patients the gallbladder visualized and in 16 patients the gallbladder failed to visualize at the initial cholecystography. Six of the latter group had cholecystograms after the signs and symptoms of the disease had subsided, which revealed a normally visualizing gallbladder (Fig 1 and 2). In five cases cholecystography was not repeated. The remaining five cases in which the gallbladder did not visualize during the acute stage of pancreatitis were subjected to laparotomy, the gallbladder appeared grossly normal in all cases, and was within normal limits by microscopic examination in the three cases in which the normal appearing gallbladder was removed (Fig 3 and 4). Patients with evident cholecystitis and pancreatitis were excluded from this case study.

The eleven cases of acute pancreatitis with temporary failure of gallbladder visualization in which subsequent cholecystography or operation demonstrated an essentially normal gallbladder are summarized as follows:

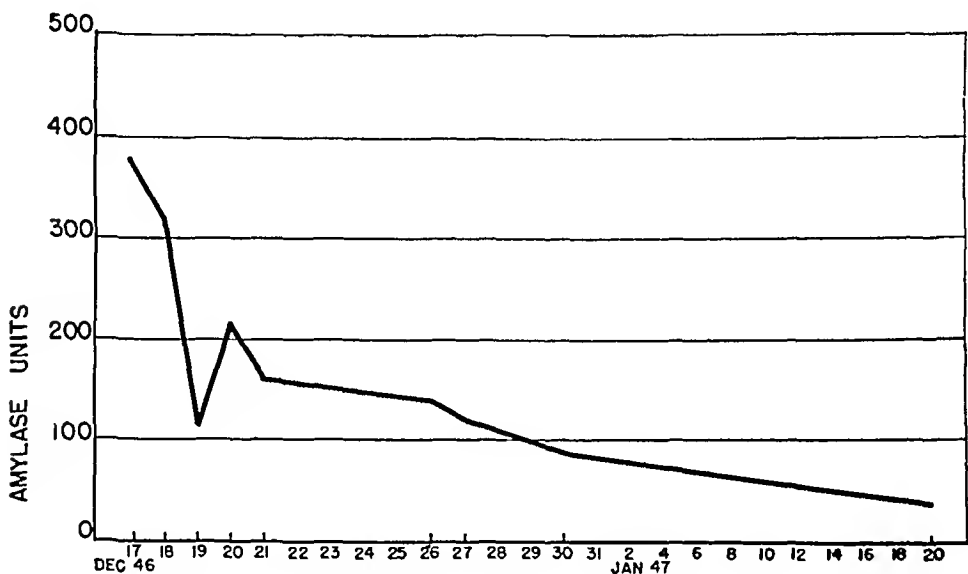
Case 1 A man 52 years of age complained of intermittent abdominal pain, nausea, and vomiting of six days' duration. Examination revealed diffuse abdominal tenderness most marked in the epigastrium. The highest blood serum amylase reading was 922 Somogyi units. Liver function tests were not done. All symptoms and signs of the disease subsided under conservative treatment over a period of four days. The gallbladder failed to visualize by the intravenous iodekon method on the sixth day of the disease. However, on the twenty-third day, 13 days after the acute episode of pancreatitis had subsided, intravenous cholecystography revealed a normal gallbladder visualization.

Case 2 During a period of four months a woman 68 years of age had three episodes of nausea, vomiting, and epigastric pain radiating to the back and shoulders. Her most recent illness began seven days before examination. The epigastrium and right lower abdomen were tender. The highest serum amylase reading was 502 Somogyi units. Icterus index, blood serum proteins, and sodium benzoate conjugation were within the limits designated as normal. The gallbladder failed to visualize by the intravenous iodekon method on the seventh day of the last acute episode of pancreatitis. The acute symptoms and signs of the disease subsided over a period of six days under conservative management. On the 19th day, six days after the acute pancreatitis subsided, the gallbladder visualized normally by intravenous cholecystogram.

Case 3 A man 32 years of age gave a history of two episodes of cramping epigastric and generalized abdominal pain. Also there was a history of alcoholism. The more recent attack began seven days before examination. There was a moderate degree of tenderness in the epigastrium. The highest blood serum amylase reading was 449 Somogyi units. Bromsulphalein excretion, cephalin flocculation, blood serum proteins, prothrombin time and serum cholesterol were within the limits ordinarily designated as normal. The gallbladder failed to visualize by the intravenous iodekon method on

the seventh day of the recent episode. The acute symptoms and signs subsided with conservative treatment over a period of twenty-four hours. On the 16th day, nine days after the acute pancreatitis subsided, the gallbladder visualized normally following the intravenous administration of iodekon.

Case 4 A man 32 years of age had four attacks of nausea, vomiting and epigastric pain over a period of three years. Examination three days after onset of the most recent attack revealed diffuse abdominal tenderness, most marked in the epigastrium. The highest blood serum amylase reading was 582 Somogyi units. Blood serum cholesterol, proteins and icterus index were within the limits of normal. The gallbladder failed to visualize by the intravenous iodekon method on the third and on the fifth days of the acute illness. The symptoms and signs of the acute illness subsided rapidly under conservative treatment. On the 27th day following the onset of the illness the gallbladder visualized normally by intravenous cholecystography.



(5) E D

FIG 1 Case 5 Acute pancreatitis Blood serum amylase Determinations expressed in Somogyi units

Case 5 A man 29 years of age had two attacks of epigastric pain with nausea and vomiting in a period of four years. Two days after the beginning of the more recent attack examination revealed tenderness in the epigastrium and periumbilical regions. The highest blood serum amylase reading was 376 Somogyi units. With conservative management the symptoms and signs of the disease subsided over a period of four days. The gallbladder failed to visualize by the intravenous iodekon method on the second day of the acute illness, but visualized normally on the 38th day, 32 days after the signs and symptoms of acute pancreatitis had subsided.

Case 6 A man 55 years of age complained of epigastric and left subcostal pain of two days' duration. There was tenderness and spasm in the epigastrium and lower right abdomen. Maximum blood serum amylase reading was 264 Somogyi units. Icterus index and blood serum proteins were within the limits of normal. Over a period of two days the signs and symptoms of the disease subsided with conservative treatment. On the second day of the acute illness the gallbladder failed to visualize by the intravenous iodekon

TABLE I—*Cholecystography in 28 Patients with Acute Pancreatitis*

	Number of cases
Normal gallbladder visualization during acute pancreatitis	12
Temporary failure of gallbladder visualization during acute pancreatitis, normal visualization after disease subsided	6
Temporary failure of gallbladder visualization during acute pancreatitis, normal gallbladder found at operation	5
Failure of gallbladder visualization during acute pancreatitis, subsequent visualization or operation not done	5
TOTAL	28

method, but it visualized normally on the 23rd day, 19 days after the acute signs and symptoms of pancreatitis had subsided

Case 7 A woman 43 years of age had repeated attacks of epigastric and right upper abdominal pain over a period of two weeks Examination two days after the onset of the most recent episode revealed tenderness in the epigastrium The maximum blood serum amylase reading was 1100 Somogyi units Liver function tests were not done At this time the gall bladder failed to visualize by the intravenous method Laparotomy on the same day revealed an acute pancreatic edema but the gallbladder appeared perfectly normal The patient promptly recovered but had a recurrence one month later

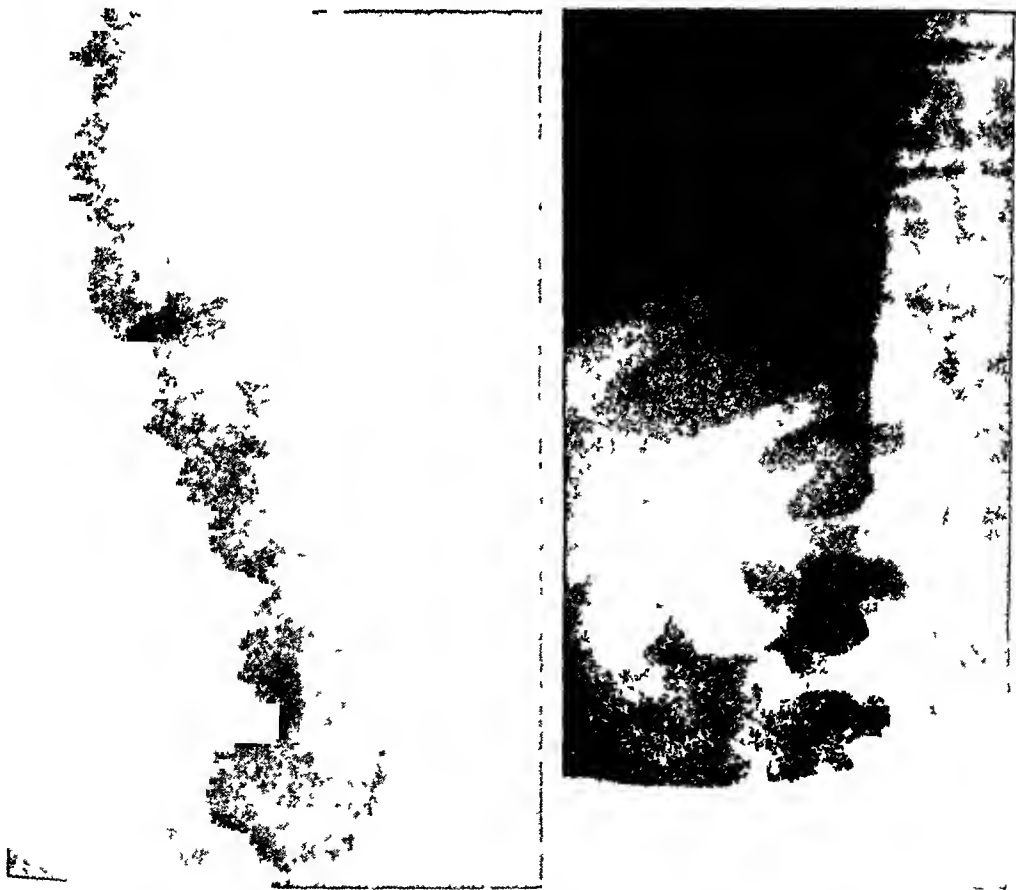


FIG 2—Case 5 Intravenous cholecystography Left, on second day of acute pancreatitis gallbladder did not visualize Right, on 38th day, 32 days after acute pancreatitis subsided, normal gallbladder visualization

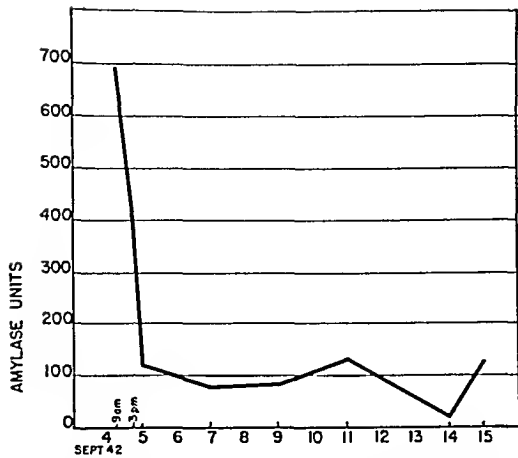


FIG 3—Case 9 Acute pancreatitis. Blood serum amylase determinations expressed in Somogyi units

ing of six days' duration. Examination revealed tenderness and rigidity in the upper abdomen. The maximum blood serum amylase reading was 690 Somogyi units. The sodium benzoate conjugation test was within normal limits. The gallbladder failed to visualize by the intravenous iodekon method on the sixth day of the acute illness. Symp-

Case 8 A man 43 years of age complained of epigastric and right lower abdominal pain with nausea and vomiting of two days' duration. The patient appeared very acutely ill and there was spasm and tenderness throughout the upper abdomen. A serum amylase and liver function determination were not done. The gallbladder failed to visualize by the intravenous iodekon method. Laparotomy performed on the second day of the illness revealed an acute hemorrhagic pancreatitis. The gallbladder appeared normal. The patient died shortly after the operation.

Case 9 A man 47 years of age complained of epigastric pain, nausea and vom-



FIG 4 Case 9 Left, the gallbladder does not visualize by intravenous cholecystogram on sixth day of an attack of acute pancreatitis. Right, normal histologic appearance of the wall of the normal appearing gallbladder removed at operation.

toms of the acute illness subsided in 24 hours. Laparotomy revealed an indurated pancreas. The gallbladder was removed and found to be grossly and histologically normal. The patient recovered promptly.

Case 10 A man 50 years of age complained of nausea, vomiting, and epigastric pain radiating to the back of five days' duration. There was tenderness to palpation deep in the epigastrium. The maximum blood serum amylase reading was 553 Somogyi units. The gallbladder failed to visualize by the intravenous iodekon method. Sodium benzoate conjugation and prothrombin time were normal. The acute symptoms and signs of the disease subsided in two days. Laparotomy revealed an indurated pancreas. The liver and gallbladder appeared to be normal. Cholecystectomy was performed. Gross and histological examination revealed a perfectly normal gallbladder. The patient recovered.

Case 11 A man 55 years of age complained of severe epigastric and generalized cramping abdominal pain of ten days' duration. Examination revealed tenderness and rebound tenderness in the upper abdomen. The blood serum amylase was 265 Somogyi units. The icterus index and Rose Bengal excretion tests were within normal limits. The gallbladder failed to visualize by the intravenous iodekon method. The acute symptoms of the disease subsided over a period of three days. At laparotomy the pancreas appeared edematous and indurated, the liver and gallbladder appeared normal. Cholecystectomy was performed. The gallbladder was normal by gross and histological examination. The patient recovered.

From this group of cases it appears that in some patients with acute pancreatitis, the ability of the apparently normal gallbladder to concentrate iodekon was lost temporarily during the acute phase of the illness. No evidence of impairment of hepatic function was found in those cases in which liver function tests were done, and none of the patients were jaundiced. Elman¹ mentions this phenomenon but does not explain it. The reason for temporary failure of gallbladder visualization by cholecystography in this selected group of patients with acute pancreatitis is not apparent at present.

SUMMARY

In a selected group of 28 patients who had cholecystograms made during the acute phase of illness with acute pancreatitis the gallbladder visualized normally in 12 cases and failed to visualize in 16 cases. In six patients in the latter group the failure of the gallbladder to visualize during the acute illness was temporary, and additional cholecystograms made after the acute pancreatitis had subsided gave normal visualization of the gallbladder. In five other patients the gallbladder failed to visualize during the episode of acute pancreatitis but the gallbladder was found to be normal at operation. In the remaining five cases in which the gallbladder did not visualize during acute pancreatitis no follow-up cholecystography or operation was done.

Explanation of this phenomenon of temporary failure of visualization of the apparently normal gallbladder in this selected group of patients with acute pancreatitis is not apparent.

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A DEPENDABLE METHOD FOR CONSTANT INTRAVENOUS THERAPY IN INFANTS USING POLYETHYLENE TUBING

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MAJOR SURGICAL PROCEDURES in infants and small children present many special problems, not the least of which is the technical difficulty of administering fluids and blood intravenously. The loss of 100 cc of blood in a small infant during an operation may be unavoidable. This amount, though negligible in a large child or adult, represents a significant percentage of the blood volume of a small infant and must be quickly replaced.

It has been common practice for many years at The Children's Hospital to have a constant intravenous infusion running before any major surgical procedure is undertaken either in infants or children. In the past this has been accomplished by making a small incision over the medial malleolar vein, isolating it, and inserting into it a blunt No. 19 or No. 20 gauge needle which can be tied in place. This method has been satisfactory in larger children, but in infants it has been difficult at times to place the needle properly in the vein and to maintain its patency when the infant is moved on the operating table or during long operations. Such needles require almost constant attention because the incidence of clotting in the needle is high, particularly in small infants when the fluid must drip slowly before operation. This clotting has often stopped the flow of blood into a vein at a critical point in an operation.

A modification of the method has been sought and preliminary experimentation was carried out on animals before the method to be described below was adopted for use in infants. Myers¹ has described a method of inserting a plastic tubing through a large bore needle in adults for repeated administration of intravenous medication. This method is hardly applicable to infants, in whom the veins are not large enough to accommodate the large needle necessary for the insertion of a tubing. Advantage has been taken of a new plastic, polyethylene (polythene),† which can be made in the form of film or tubing and which is flexible, semi-transparent, tough, light, and easily sterilized. When obtained in absolutely pure form it has been found by Ingraham, Alexander and Matson² to be non-irritating to tissues and as well tolerated.

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as tantalum, vitallium and methylmethacrylate. Diamond and Thomas³ have used polyethylene tubing in replacement transfusions of newborn infants with *erythroblastosis fetalis*. They have encountered no difficulty with clotting in the tube, which is placed in the umbilical vein of the infant. It has been possible for them to perform replacement transfusions of over 500 cc by this method.



FIG 1—Leg of infant secured to padded board with adhesive strips. Polyethylene tube inserted into internal malleolar vein under local Procaine anesthesia. Whole blood running through tube.

TECHNIC

The infant is lightly secured to a wheeled litter in a room adjoining the main operating room. The leg is strapped to a padded board as shown in the accompanying photograph (Fig 1). The skin is prepared as for any surgical procedure and draped with sterile towels. The region over the internal malleolar vein is infiltrated with 1 per cent procaine. The instruments and drapes supplied for this procedure include gown and gloves, basins for solutions used in preparing the skin, 1 per cent procaine, 2cc syringe, four hemostats, a pair of small forceps, a small scalpel, scissors, a fine nerve hook, silk sutures, gauze sponges, towel clips and a No 18 needle.

A piece of polyethylene tubing 30-40 cm in length is provided. Two sizes of tubing are used, one with an outside diameter .067 and an inside diameter of .047 into which an No 18 needle fits snugly, and a second less frequently used size (outside diameter .050, inside diameter .034) which accommodates a No 19 gauge needle. The tubing is sterilized by soaking in a 1:1000 aqueous solution of Zephiran for 18 to 24 hours. Attention should be directed to the necessity for filling the lumen of the tubing with the solution and to weighting the tubing to the bottom of the solution pan with a material heavier than water.

An incision 1.0 to 1.5 cm long is made transversely just lateral to the medial malleolus. If the medial malleolar vein is excessively small or has been previously utilized in other operations, the veins over the radial side of the wrist or in the antecubital space are employed. The tissues are spread, the vein picked up with a nerve hook, and the vein freed from the surrounding tissue for a distance of 1 cm. A silk tie is placed on the vein distally for use in traction. The end of the plastic tubing is bevelled with scissors. A small opening is made

with the scissors and the tubing inserted while traction is exerted on the suture distally. Ordinarily the tubing can be inserted easily 6 to 10 cm into the vein, but it will usually function satisfactorily if inserted only 1 to 2 cm. It is withdrawn about 10 cm to obviate the possibility of the end of the tubing being lodged against a valve in the vein. A piece of fine silk is then placed around the vein and tubing within it and tied securely. Two silk sutures are used to approximate the skin edges.

A segment of tubing about 25 cm in length is allowed to extend from the wound and it is secured to the foot and ankle by two pieces of adhesive tape (Fig 2). The tubing is attached to a needle which in turn is joined to a rubber tubing and buret by means of a syringe with a sidearm or an ordinary glass adapter. A glass drip is incorporated in the rubber tubing so that the rate at which the fluid is running can be accurately determined.



FIG 2—Leg removed from restraining board. Transparent polyethylene tube secured to foot by two small pieces of adhesive. Wound covered by sterile dressing. Distal end of tube connected to sidearm syringe of intravenous drip set by No. 18 gauge needle which fits snugly into tube.

The leg is removed from the board to which it was secured during the insertion of the intravenous tubing. It is not immobilized. General anesthesia is then begun and the patient transported to the operating room.

The patient is usually taken to the ward after operation with the intravenous tubing in place. This can be done either with the intravenous solution dripping or with a small syringe attached to the tubing, the tubing irrigated with isotonic saline solution, and the plunger of the syringe held in the closed position with a strip of adhesive (Fig 3). It is possible to resume the administration of fluids through the tubing several hours later merely by attaching another rubber tube with glass adapter to the plastic tubing. The syringe has been left in place on the plastic tubing as long as 18 hours on several occasions and the administration of fluids resumed again without difficulty.

It has been the usual practice to remove the tubing from the vein within 24 hours after its insertion, but in many instances the tubing has been left in

place 48 hours or more, and in one instance it was allowed to drip continuously for five days. The tubing has occasionally been left in place longer than 48 hours either because of the necessity for administering fluids to a seriously ill infant without further disturbances to the patient, or, during the period of development of the method, to determine its feasibility for prolonged administration of fluids to infants with diarrhea, nutritional disturbances, and those unable to take fluids by mouth. In no instance has blood clotted within the polyethylene tube so that it was impossible to resume the administration of fluids.

DISCUSSION

This method of administering intravenous fluids and blood has been used in over 90 cases on the neurosurgical service since January 1, 1947, and it has



FIG 3—After operation the infusion of intravenous fluids may be discontinued for 18-24 hours and started again through the same plastic tube. The tube is irrigated with isotonic saline. Plunger of syringe held in closed position with adhesive to prevent reflux of blood into the tube. Syringe secured to lower leg. Intravenous drip begun again by reconnecting set containing fluid to the plastic tube.

been found to have many advantages over the methods previously employed. The most valuable feature of this method is its dependability. Only once during the six months' period of its use during all major neurosurgical procedures at The Children's Hospital has there been any difficulty with the administration of blood during an operation. In that case the tubing had been inserted through the wall of the vein and was not lying in the lumen. In all other instances it has been possible to administer whatever fluid or blood was necessary, in some cases up to 1500 cc of blood over a period of less than 45 minutes.

The ease with which the tubing can be placed in the small veins of infants is also a distinct advantage. The tubing is placed in the vein by the house officer on the service before the anesthesia is started. In most cases the house officer has had only a few months of surgical training, but even in inexperienced hands, the insertion of the tubing rarely requires more than a few minutes.

One disadvantage of this method should be mentioned. Although citrated whole blood will run by gravity through the tubing as slowly as desired, it will not run so rapidly as is sometimes needed to replace blood lost during a major operation. It is therefore necessary to pump whole blood by means of a syringe attached to a three-way stopcock in the rubber tubing of the intravenous set. It has been found possible to transfuse large amounts of blood by this means without difficulty. Even if blood does reflux from the patient into the plastic tubing and form a small clot at the end of the tube, it is easy to dislodge the small clot with a syringe filled with saline attached to the needle of the tubing.

The problem of superficial phlebitis following the insertion of any constant intravenous needle or tubing is an ever-present one. In the 90 patients with whom this tubing has been used, eight cases of superficial phlebitis have been observed, all of which subsided rapidly after the tubing was removed. None of them have resulted in further complications or in residual swelling of the leg. In only one case has the superficial phlebitis been found to occur under the 24-hour period, and only four cases developed superficial phlebitis under the 48 hour period. In at least two of these hypertonic solutions such as "Amigen" or 10% dextrose in water were administered. All of the other instances of phlebitis resulted after periods of more than 48 hours and in no case was there evidence of infection in the wound itself, or of any reaction to the tubing. Deep phlebitis did not occur in any of the cases.

The greatest value of the method lies in its dependability during major surgical procedures in infants and the relative simplicity with which it can be employed even by those not extensively trained in surgical technic. If, therefore, the tubing were routinely removed before the end of the 24-hour period after insertion, and if only relatively isotonic solutions and blood were administered, the complication of phlebitis would be practically non-existent.

SUMMARY

- 1 A technic for administration of fluids and blood intravenously to small infants during surgical procedures has been described.
- 2 The success of the method depends upon the non-irritating qualities of a new plastic tubing, polyethylene, in which the whole blood shows delayed clotting.
- 3 The method is dependable and easily employed, even by inexperienced persons.
- 4 It has been found useful in over 90 major neurosurgical procedures and is of benefit in the administration of fluids during the postoperative period.
- 5 Superficial phlebitis occasionally develops but in only one case did it develop when the tubing had been in place less than 24 hours, and in only four cases under 48 hours.

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PHLEBOGRAPHY IN THE LOCALIZATION OF INCOMPETENT COMMUNICATING VEINS IN PATIENTS WITH VARICOSE VEINS*

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Since high ligation was first proposed as a remedy for varicosities of the long saphenous system, it has been recognized that this procedure would produce a lasting cure only if the valves of the communicating veins were competent. Various clinical methods have been devised for testing this competency^{1, 2, 3}. Although selection of patients for high saphenous ligation is made only after the performance of one or more of these clinical tests, the incidence of postoperative recurrence of varicose veins remains disappointingly large. The failure of high ligation has been attributed by Sherman⁴ to incompetence of communicating veins not revealed by the usual tourniquet examinations. He has demonstrated incompetence at operation in cases in which tourniquet tests were negative. It is apparent that a more accurate method of detecting incompetent communicating veins would improve the results of operation for varicosities. It is the intention of this paper to introduce phlebography for this purpose.

METHOD

Each patient with varicose veins is first subjected to the usual clinical examination including Trendelenberg tourniquet tests. If the varicose veins fill below a high thigh tourniquet within 30 seconds, the incompetent communicating veins are localized between two tourniquets.

Next a phlebogram is performed by the following technic. Three tourniquets are placed respectively, just above the malleoli, a few centimeters above the femoral condyles, and as high as possible on the thigh. All three tourniquets are adjusted to hinder but not completely obstruct the flow of blood through the deep veins. The patient is placed in the supine position and a 20 gauge needle introduced into one of the superficial veins on the dorsum of the foot. 30 cc of 35% diodrast are injected rapidly. Antero-posterior and lateral roentgenograms are taken of the lower leg. The ankle and the low thigh tourniquets are released and an AP plate is taken of the thigh.

The roentgen-ray appearance of incompetent communicating veins varies. Of the two communicators visible in Fig 1, the lower one (B) may be fol-

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lowed readily from its posterior tibial vein origin to the saphenous vein, whereas the upper communicator is visible only for a short distance beyond its origin

Communicating veins frequently occur in pairs especially on the lateral aspect of the leg. Actually the paired veins are vena comities of a small artery which is usually dwarfed by the dilated and tortuous veins which accompany it

It is not necessary to distinguish antero-medial from postero-medial com-



FIG 1—Two incompetent communicating veins are readily visible on the medial aspect of the leg, the lower one (B) empties into a dilated superficial varix at a site at which ulcer formation is frequent

municating veins. However, because of the arrangement of the fascial compartments on the lateral side of the leg, it is desirable to determine whether a particular vein passes behind or in front of the fibula. By correlating the lateral with the antero-posterior roentgen-ray exposure it is possible to localize the veins fairly accurately

Incompetence is not often encountered in the veins which connect the superficial and deep venous systems in the thigh. Furthermore the venous connections between the two systems are of the nature of perforating veins rather than true communicating veins. In addition to the anatomic patterns described by Sherman on the medial aspect of the thigh, there also seem to

be perforating veins on the lateral aspect which empty into the profunda femoris

Two sources of error are demonstrated in Fig 5. Incompetent communicating veins will often not be detected if there is incomplete filling of the deep veins with which they communicate. On the other hand superficial veins which have been filled from an incompetent communicator above or below may overlap the deep system so as to simulate perforating or communicating veins.

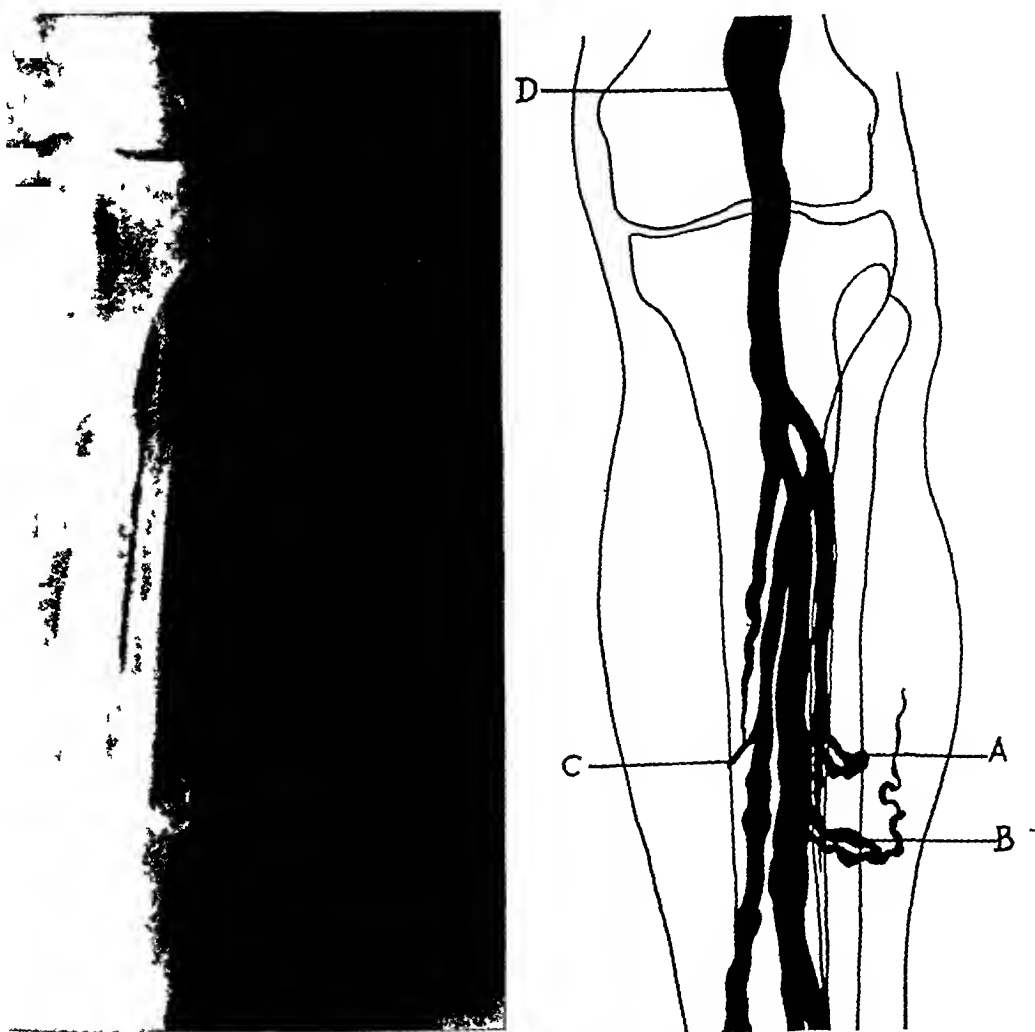


FIG 2—(A) and (B) each denote a pair of dilated lateral communicating veins and (C) a medial vein which were confirmed at operation. One medial communicator was found by stripping at (D) but did not appear in the phlebogram or by tourniquet examination.

In order to test the comparative accuracy of the two methods used for localizing incompetent veins, a rather radical operative procedure is carried out. After the conventional high saphenous vein ligation, a Sherman⁵ type of stripping is performed. In addition, longitudinal incisions are made in the deep fascia of the lower leg at all sites where the presence of incompetent communicating veins has been suggested either by tourniquet test or by phlebogram. Through these incisions the fascia is undermined in the manner described by Linton,⁶ thus allowing visualization of the communicating veins.

as they pass through the fascia overlying the muscles. It has been observed that many of these communicators do not connect directly with the main saphenous trunks and would consequently be overlooked even on the medial aspect of the leg if only a stripping were performed.

RESULTS

A careful record has been maintained on each patient for comparison of the results of tourniquet test, phlebogram and operative findings respectively.

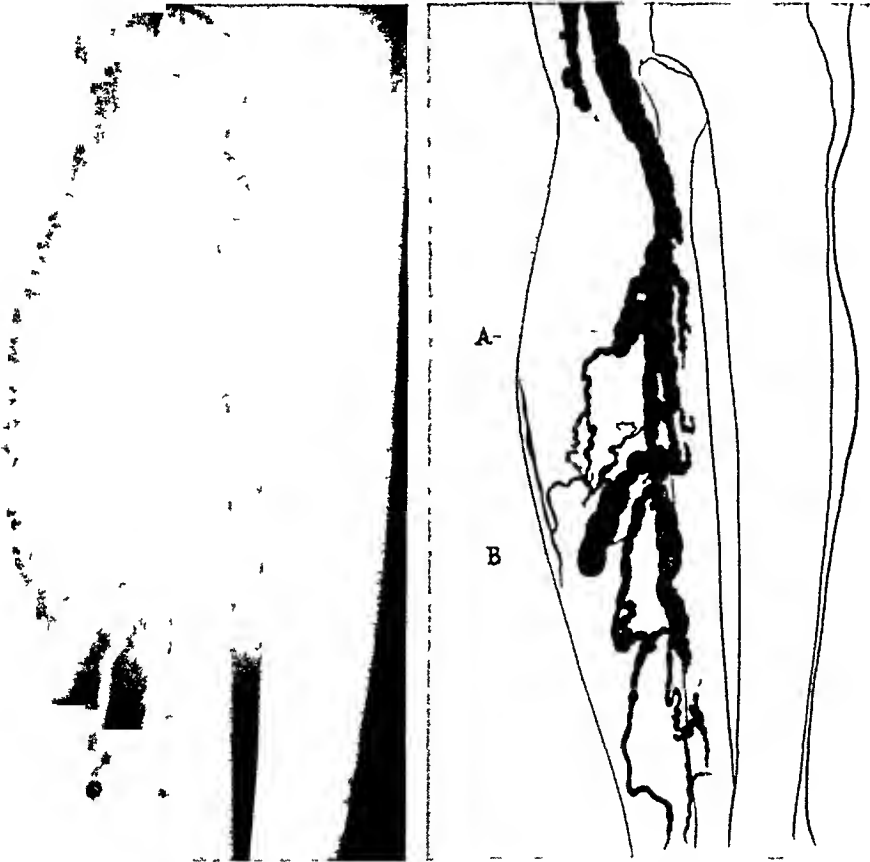


FIG 3—Lateral view of lower leg shows two large incompetent perforating veins through which the short saphenous system is filled. It is obvious that high ligation of the short saphenous vein would alone be of little value in this case.

So far twenty patients have been studied. The results are tabulated in Table I and Table II.

Neither the tourniquet examination nor phlebography correlates completely with the operative findings. However, only 54% of the incompetent veins localized by tourniquet preoperatively were confirmed by surgery whereas the results of roentgen-ray localization were confirmed in 86%. Many of the false positives by phlebography represent errors in interpretation of the roentgen-ray findings. These errors have now been largely eliminated with more experience.

TABLE I

*Preoperative
Localization of incompetent
communicating veins*

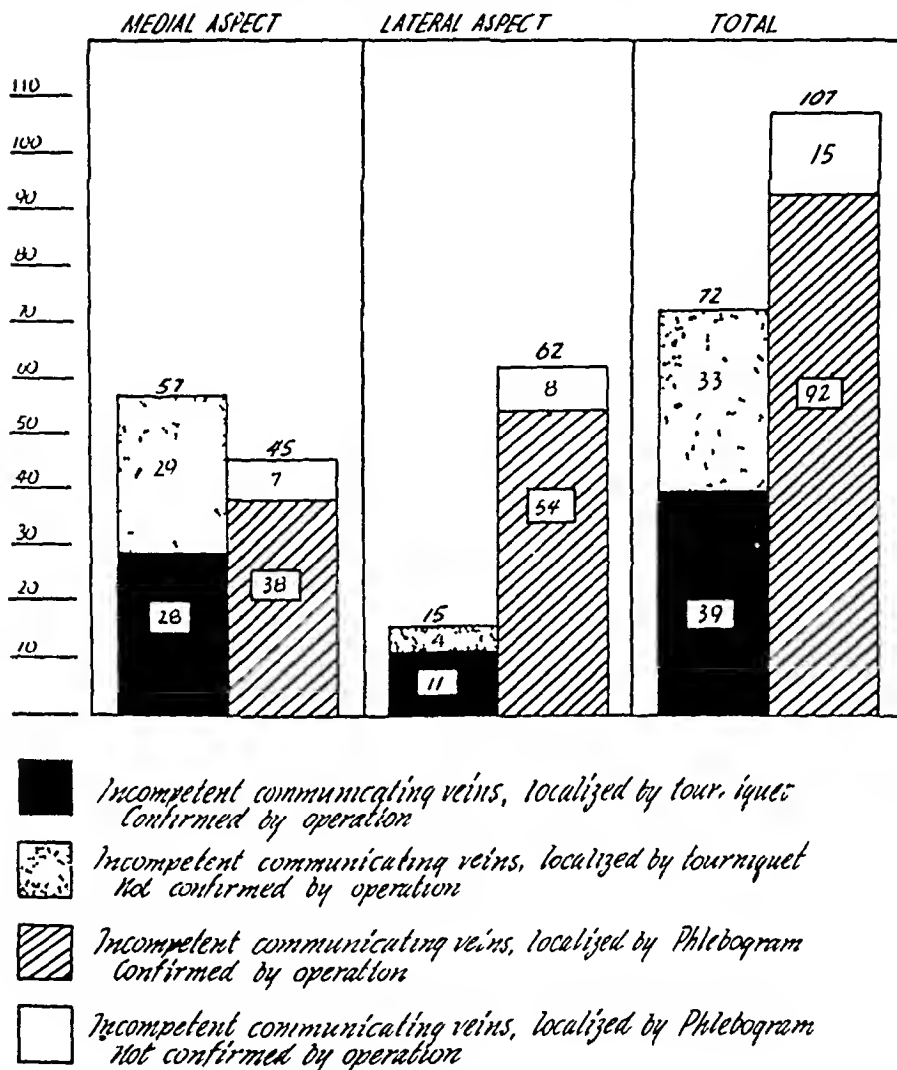


TABLE I—The numbers of incompetent communicating veins indicated respectively by tourniquet examination and by phlebogram are charted side by side. The shaded lower portion of each bar represents the number of incompetent communicators confirmed by operation and the light upper portion represents the number not found by operative exploration. The latter may be termed false positives. The accuracy of phlebography is obviously greater for medial communicating veins as well as over all but the proportion of false positives is about equal on the lateral side of the leg for tourniquet and Roentgenogram.

When the postoperative findings are analyzed it seems that tourniquet examination, with a localization accuracy of only 29%, compares poorly with phlebography, with an accuracy of 69%. Actually the operative findings are themselves not necessarily completely accurate. Probably some communicating veins indicated by clinical or roentgen-ray examination were missed at operation because of inadequate exploration. Furthermore, the decision as

TABLE II

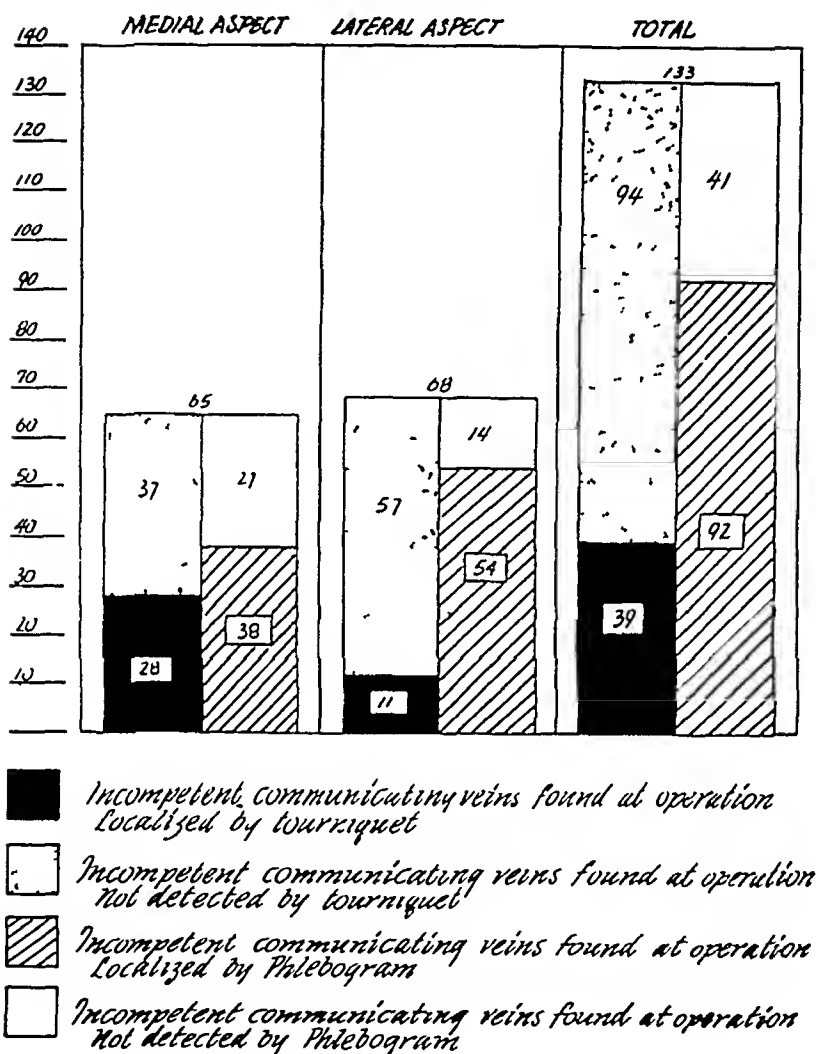
Operative localization of incompetent communicating veins

TABLE II—The number of incompetent communicating veins actually found at operation is indicated. Again the two methods of localization are charted side by side. The dark lower area of each bar represents the incompetent veins which were localized correctly before operation. The lighter upper area indicates the number which were missed pre-operatively. Here the huge difference between tourniquet and phlebogram on the lateral leg is striking.

to competence or incompetence at operation is necessarily based on the size and tortuosity of the communicating veins. Some of those which were classified as incompetent may have been large but nevertheless still competent. In a dissecting room study of the position and size⁷ of the lower leg communicating veins, one of us has observed the frequent occurrence in normal

legs of rather large veins connecting the long saphenous with the deep venous system

DISCUSSION

Clinical examination by tourniquet test or similar methods is necessarily inaccurate for localizing incompetent communicating and perforating veins, especially below the knee, since the segments of superficial vein which become visible between tourniquets are usually not directly over the incompetent communicating veins. This difference between the location of the visible varicosities and that of the incompetent connections through which the former are



FIG 4—Phlebogram of thigh which shows at (A) an incompetent vein corresponding to the mid-Hunter canal perforator of Sherman. The tortuous dilated vein seen at (B) seemed to have no connection with the superficial system which would be demonstrated at operation.

filled is especially manifest when the communicating veins are on the lateral half of the leg. Thus only 16% of the incompetent communicators in this location were detected by tourniquet examination.

The false positives of clinical examination were chiefly on the medial aspect of the leg where over 50% of the incompetent veins indicated prior to operation were not confirmed at surgery. The chief source of error here was probably the effect of pooling of blood in large saccular varices.

The use of phlebography in patients with varicose veins has previously been limited to demonstrating patency of the deep venous system. The rationale of the technic here used is as follows. The tourniquet above the malleoli blocks the superficial venous channels forcing the injected material into the deep veins. As long as the deep channels are free of obstruction the opaque medium does not return to the superficial veins. However, the two



FIG 5—Six lateral incompetent communicators are indicated. One each at (A) and (B), two each at (C) and (D). A medial vein is seen at (F). All were proven at operation. Additional communicating veins were found at surgery at (G) and (H), where the posterior tibial veins are not well visualized. On reviewing the plebogram, after operation, a faint but definite outline of a communicating vein was observed at (G). There seems to be a medial communicator at (E) but this is an artefact. Actually it is a superficial tributary of the saphenous vein which overlies the posterior tibial veins.

tourniquets on the thigh provide enough obstruction to normal flow to cause the diodrast to pass retrogradely through incompetent communicating veins back to the superficial system. In an extremity with competent valves in the communicating veins, the opaque medium forces its way by the tourniquets instead of through the competent communicating veins.

Thus the visualization of any communicator or perforator by roentgen-ray would depend upon the competency of the valves and be more or less indepen-

dent of the size of the vein. In this respect the phlebogram may be more accurate than the operative findings. On the other hand incompetent communicating veins will be visible by roentgen-ray only when there is good filling of the deep veins with which they are connected. It is difficult to get a good injection of all three pairs of deep veins in the lower legs. The anterior tibials are the most difficult to visualize and at times the posterior tibial veins are not completely filled. Visualization of the peroneal veins is almost always excellent. Recently, by simultaneous injection of two superficial veins on opposite sides of the foot, we have been able to fill all six deep veins in some cases. Non-filling is the basis for most of the missed communicating veins.

With improvements in roentgen-ray technic and interpretation, it is possible that incompetent communicating veins may be localized with sufficient accuracy to justify a new type of operative procedure for varicose veins. This would consist of a high saphenous vein ligation supplemented by local subfascial exploration limited to those sites at which incompetent communicating veins have been demonstrated by phlebography.

SUMMARY

The late results of varicose vein treatment by high saphenous vein ligation are unsatisfactory because of the presence of incompetent communicating veins not detected by tourniquet examination. A phlebographic technic for localizing incompetent communicators is described along with the operative findings in 20 patients. The phlebogram seems to offer a more accurate method than clinical examination for detecting and localizing incompetent communicating veins. Phlebography is particularly useful for mapping lateral communicators which can not otherwise be detected.

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PERFORATION OF ILEUM BY INGESTED CHICKEN BONE COMPLICATING VENTRAL HERNIA*

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THE PURPOSE OF THIS REPORT IS to present an unusual case and a discussion of ingested foreign object perforations with special reference to this complication in hernias

CASE REPORT

Patient A L, a 51-year-old white male of Czechoslovakian birth, entered St Luke's Hospital at 7 15 A M on April 5, 1945 For the past five years, following an appendectomy through a right rectus incision, he had noted a ventral hernia of increasing size Seven hours prior to admission, acute cramp-like pains were noted in and around the hernia with marked tenderness of the hernia He complained of nausea and belching, but had not vomited A normal bowel movement three hours prior to admittance was reported to have offered no relief from the pain The past history, except for appendectomy and subsequent hernia, was negative

Examination revealed an obese white male, anxious and obviously in pain BP—125/90, Temp—100.2 (oral), Pulse—132, Resp—32 Complete upper and lower artificial dentures were present Neck, heart and lungs were normal A grapefruit-sized ventral hernia protruded from the right para-umbilical region It was tender, hot and irreducible Bowel sounds were not present within the hernia, and were heard but occasionally in the adjacent abdomen Laboratory RBC—4,600,000, WBC—10,650, Hgb—14.6 Gm, urine-chemical and microscopic, negative

A diagnosis of strangulated ventral hernia was made, and immediate operation advised

Operation was carried out under ethylene-nitrous oxide anesthesia supplemented with curare intravenously as needed for additional relaxation The old lower right rectus skin scar was excised The hernial sac was dissected out and opened It contained several loops of ileum, three of which were markedly hyperemic and covered with fibrinous exudate Remaining loops were only slightly cyanotic Purulent exudate with a foul odor was present in the sac Two loops of ileum deep in the inferior portion of the sac were found to be adherent to the peritoneum lining the sac Both fibrous and fibrinous cohesion was encountered In the course of freeing one of the loops, a chicken bone fragment was discovered protruding through a necrotic patch on the antimesenteric margin of the ileum The bone was extracted after enlarging the perforation The serosal fat tags were cleaned from the surrounding ileal surface and purse string closure made As none of the involved intestine presented permanent circulatory embarrassment,

* The assistance of Miss Angeline McNeil St Luke's Library, is gratefully acknowledged

all loops were reduced into the abdominal cavity. The excess sac was trimmed away and a layer closure of the defect was carried out. Single o chromic catgut was used to imbricate the peritoneum and posterior rectus sheath, and interrupted #20 cotton sutures were used in the anterior rectus fascia. Sulfanilamide crystals were dusted between the layers.

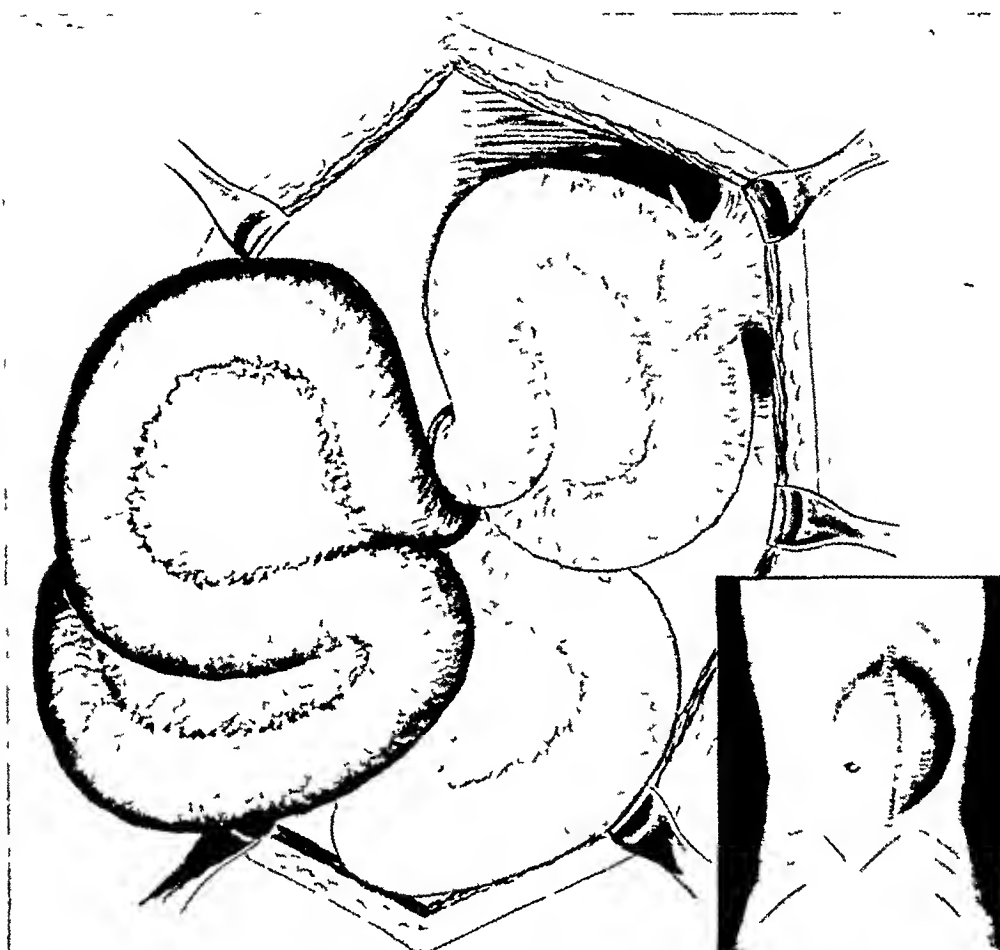


FIG 1—A sketch of the opened sac of the ventral hernia showing adherent ileum which has been perforated by chicken bone (lower left). Inset represents site and size of hernia.

TABLE I—Age and Sex of Patients Presenting Foreign Body Perforations in Hernias

Adults	31	Males	19
Children	7	Females	14

TABLE II—Types of Hernia in Which Foreign Bodies Have Been Found

Inguinal	24	Umbilical	5
Femoral	4	Incisional	2
Epigastric	1		

The patient withstood the procedure well. A severe test of the closure was encountered when the patient underwent a reaction of marked excitement during recovery from the anesthetic. Supportive intravenous fluids, vitamins B and C, and sodium sulfadiazine were given for four days after which the patient resumed oral feedings. Oral sulfadiazine

was continued for eight days. The maximum temperature of 101.2 was reached on the third postoperative day. A moderate amount of induration appeared late in the lower angle of the wound, was followed by serous drainage for a few days, then complete healing. The patient was discharged, well, after seventeen days of hospitalization. When last seen six months following operation, his wound was firmly healed and his general condition good.

History obtained subsequent to operation included his recollection of inadvertently swallowing the chicken bone about two weeks prior to the acute episode.

DISCUSSION

The ingestion of foreign objects is undoubtedly quite a common occurrence. Perforations of the gastro-intestinal tract resulting from this are fortunately much less common. In a group of 800 patients with foreign bodies in the gastro-intestinal tract observed at Boston City Hospital, Henderson and

TABLE III—*Description of Ingested Foreign Objects Causing Intestinal Perforations in Hernias*

Bones total	21	One instance each
Chicken	9	Wire
Hog	3	Nail
Fish	3	1/2 set false teeth
Frog	1	Earthen egg cup
Lamb	1	Claw of skylark
Fruit seeds	6	Head of barley
Needles	5	Lead pencil
Pins	2	

TABLE IV—*Treatment and Mortality*

	No. of Cases	Mortality
Unoperated	6	50%
Incision and drainage (including enterostomy)	6	33 1/3%
Hernioenterotomy	25	30% (Based on 17 cases)
Herniotomy and intestinal resection	5	20%
Herniotomy and appendectomy	3	0%
Total operated	37	28% (Based on 28 cases)

Gaston reported only nine perforations, with two deaths. Carp reported 43 cases of which 31 were followed, 25 were uncomplicated, 6 perforated, and 2 died. Macmanus was able to find in the literature 93 reports of perforations, noting that many cases were probably not reported, and that his review was probably not complete. An analysis of this material interestingly discloses that no part of the gastro-intestinal tract escapes perforation and that no definite conclusion can be made regarding the segment of gut most prone to perforation. However, one does note frequently that the pyloric sphincter, duodenal kinks, Meckel's diverticulum, appendix, and small bowel in a confining hernia are the sites involved. Mechanically, this is not unexpected.

The perforating agents most frequently encountered are pins, wires, bones from animal, fowl or fish, and wooden splinters. Teeth, and numerous strange pointed objects are also reported.

In adults, false dentures with concomitant alteration of buccal and pharyngeal sensitivity, apparently predispose to accidental swallowing of the objects

The reaction which accompanies a perforation varies, depending upon anatomical factors or chronicity. Ginsberg and Beller have presented the following classification:

- 1 Acute perforation with peritonitis,
- 2 Localized intra-abdominal abscess,
- 3 Intra-abdominal inflammatory tumor,
- 4 Abdominal wall inflammatory tumor,
- 5 Abdominal wall abscess, and
- 6 Perforation with inflammation and obstruction in hernia.

The symptomatology and physical findings are usually consistent with the degree of pathology.

The history of swallowing a foreign object coupled with Roentgen-ray confirmation should offer the best chance for establishing the etiology and diagnosis prior to operation. Treatment should be suited to the type of complication encountered in accordance with accepted surgical principles.

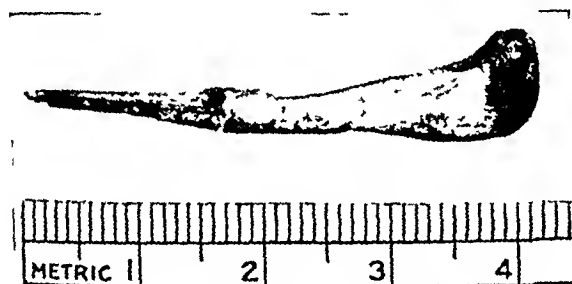


FIG. 2.—Photograph of chicken bone removed from adherent ileum in ventral hernia operation.

With our interest directed to *foreign object perforation complicating hernia*, we have made a careful search for case reports and references to this entity. Some of the material was not accessible in original articles, which accounts for lack of complete detail in the analysis to follow. The earliest case was reported

by Claudius in 1735. Fabian reviewed 35 cases in 1910, including one in which the foreign body was a gallstone and one an intestinal stone. Our study is based upon the 50 cases thus collected, and includes only perforations by ingested foreign objects.

The incidence with respect to age and sex is shown in Table I. The type of hernia involved is indicated in Table II. Of particular interest is Table III in which are listed the *corpora aliena*. The diligence expended upon proper identification of these articles is remarkable.

Variations in treatment with the associated mortalities are shown in Table IV. As one would expect, the highest death rate occurs in cases unoperated, and in those coming for treatment too late for any intervention except incision and drainage. Hernioenterotomy, which entails the extraction of the foreign body, closure of the gut, and repair of the hernia, shows a somewhat better rate at 30 per cent. In the group requiring intestinal resections, the mortality is lowest, *i. e.*, 20 per cent. This number of cases is too few to weigh properly against the previous group. Perforations of the appendix, treated by appendectomy and herniotomy, occurred three times with no deaths. The mor-

THE ACCIDENTAL OPERATIVE TRANSPLANTATION OF BENIGN GIANT CELL TUMOR

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THE NATURE OF GIANT CELL TUMOR of bone has been frequently discussed in the past few decades. In recent years it is more generally believed to be a type of benign bone tumor which may have local destructive powers with the ability to recur at the primary site and yet does not give rise to distant metastases. Meyerding⁵ has suggested the use of the terms "benign giant cell tumor" and "malignant giant cell sarcoma" to differentiate the more common type from the malignant tumor.

The possibility of metastases arising from benign cell tumor, however, has been thoroughly reviewed in the literature. It has been indicated that pulmonary metastases might be expected from this benign tumor in view of its free vascular connections and the frequent treatment by curettage. Ewing made a careful search for such cases up to 1926 and pointed out that in spite of numerous efforts, no proven cases of metastases from benign giant cell tumor had been reported. Meyerding⁶ in his large series of 40 cases treated by excision of the tumor and bone graft had no instance in which there had been a transplantation of a benign giant cell tumor.

This case report concerns the accidental operative transplantation of a benign giant cell tumor of the tibia to a distant soft tissue site over the crest of the ilium. No similar case was encountered in the literature.

J. M., a 56-year-old railroad worker was admitted to Toronto General Hospital on April 11th, 1946, with a history of intermittent swelling below the left knee for 5 months associated with slight pain and stiffness in the knee for 2 months. Five weeks before admission about 50 cc of straw colored fluid had been aspirated from the knee joint with some relief of symptoms but one week previous to admission the patient developed an acute thrombophlebitis of the left leg. On admission the left knee presented a hard diffuse slightly tender swelling in the upper end of the tibia and roentgen-ray showed an expanding osteolytic lesion of the upper end of the tibia which had broken through the cortex at the level of the tibial tubercle, (Fig 1). A biopsy of the tumor showed a typical histologic picture of benign giant cell tumor, with varying numbers of large irregular giant cells scattered throughout a fibrous tissue stroma. These giant cells had numerous hyperchromatic nuclei which were located usually in the central portion of the cell (Fig 2).

On May 8th, 1946, the tumor mass was curetted leaving a large cavity in the upper end of the tibia about four inches in length. The defect was bridged with a sliding bone graft from the tibia and the remainder of the cavity was packed with cancellous bone chips obtained from both iliac crests. The can-

cellous bone graft was removed *after* the curetting of the tumor. Figure 3 shows an immediate postoperative roentgenogram with the limb in a circular plaster. The cast was removed and reapplied after two months with no evidence of recurrence of the tumor. On October 5th, 1946, five months postoperatively the patient was readmitted and on removal of the plaster cast a moderate sized swelling of the upper end of the tibia was noted. Roentgenogram showed



FIG 1 (A)—A P X-rays to show the expanding osteolytic lesion of the upper end of the tibia—broken through at the level of the tibial tubercle (B)—Same as on Fig 1 (A)

a local recurrence of the tumor involving the whole upper end of the tibia. On October 16th, 1946, the upper end of the tibia and the tumor were excised and a massive tibial graft from the right leg was used to bridge the gap from the lower end of the femur to the middle of the left tibia. Cancellous bone chips from the upper end of the right tibia were packed about the graft. The microscopic sections of this tumor showed a recurrent giant cell tumor of bone with numerous variable sized multinucleated giant cells distributed through in-

terbranching bundles of fusiform fibroblastic cell elements. Additional sections of adjacent skeletal muscle tissue did not show any evidence of invasion of the tumor growth, (Fig 4). The limb was immobilized with external skeletal fixation but slight infection developed about the upper two Rodger-Anderson pins. As a result the Rodger-Anderson apparatus was removed and a plaster spica applied (Fig 5). Unfortunately the patient developed a mild infection in the wound at the left knee and a window was cut in the cast in the area of the sinus.

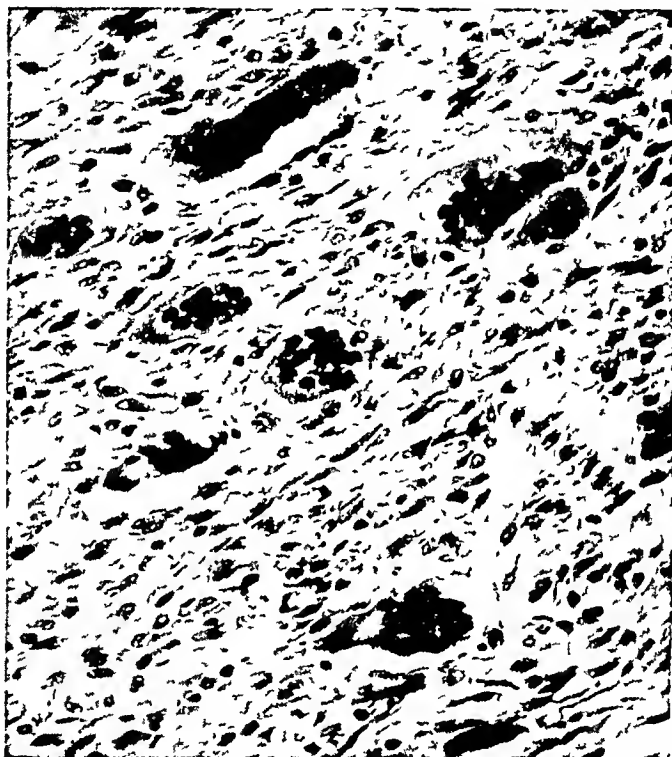


FIG 2—Biopsy from tumor of the upper end of the tibia showing varying numbers of irregular giant cells scattered throughout a fibrous tissue stroma
circular plaster

On February 22nd, the plaster spica was removed and at this time a firm mass about $1\frac{1}{2}$ " in diameter was noted beneath the scar over the left iliac crest at the site of previous cancellous bone graft (May 8th, 1946). A biopsy of this mass was taken and on March 5th, 1947, the tumor was widely excised. Figure 6 shows the gross specimen, bisected. It was situated superficially beneath the skin and was attached to scar tissue overlying the ilium. There was no attachment to bone. This implantation tumor revealed the characteristic picture of benign giant cell tumor of bone in the gross. The histologic appearance was similar to the sections previously described. In addition there were a few areas of patchy necrosis and haemorrhage (Fig 7). Careful physical examination failed to reveal any further masses and roentgenograms of the pelvis and chest were negative.

ACCIDENTAL TRANSPLANTATION GIANT CELL TUMOR

DISCUSSION

Experimentally the inoculation and implantation of malignant tumor cells have been successfully carried out under certain conditions. This has been demonstrated well by transplanting sarcoma and carcinoma in rats and mice. Ewing, in discussing the essential conditions for neoplastic growth of misplaced cells, state that the cells must possess some special capacity for



FIG 3—X-ray immediately postoperative (May, 1946) with limb in

growth, either by virtue of an embryonal character or from retention of proliferative tendencies in more than ordinary degree

Clinically, operative transplantation of carcinoma has been frequently reported in the literature. Corneli in 1891³ reported successful tumor transplantations from a malignant tumor of one breast to the other breast. Ryall, in 1907,⁹ pointed out that recurrent carcinoma was frequently due to contamination of the instruments with cancer cells. Ryall was the first to advocate a complete change of gloves, drapes and instruments followed by re-

preparation of the operative site after a biopsy of a malignant tumor Primrose in 1922³ briefly recorded a case of an ovarian malignancy in which ascitic fluid was aspirated and subsequently injected in the submammary region as an experimental therapeutic procedure, a malignant tumor appeared in the breast and axillary glands

The demonstration of viable tumor cells on instruments used for biopsy of a carcinoma of the breast was made by Saphir¹⁰ Smears were made directly

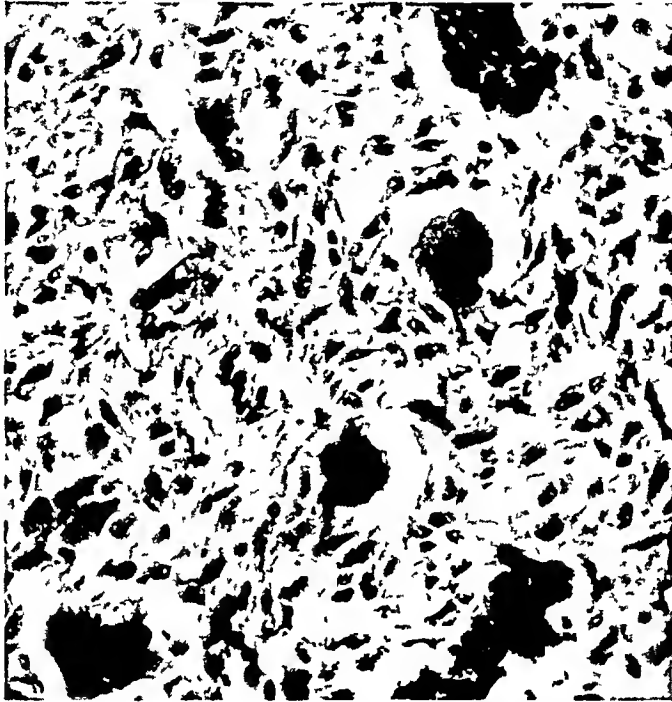


FIG 4—Biopsy from recurrence of tumor showing numerous variable sized multinucleated giant cells distributed through bundles of fusiform fibroblastic cell elements

from knife blades and from saline in which such blades had been rinsed Brandes White and Sutton¹ repeated this work and also demonstrated viable malignant tumor cells in basins of water in which the surgeon's gloves were washed The cells appeared to remain viable for longer periods in saline than in distilled water They reported a case in which it seemed evident that contamination of the gloves was responsible for transplantation of highly malignant carcinoma of the breast from the mastectomy site to a skin donor area on the left thigh

The implantation of benign tumor cells, however, appears to be uncommon Sampson studied the occurrence of endometriomata in extra genital positions and this led to his theory of endometrial transplantations Previous to this time Iwanoff (1889) and others postulated a serosal origin for peritoneal endometriomata MacLeod in his Hunterian lecture stated that invasion of

endometriomata has occurred along intertissue spaces and he favoured a theory of lymphatic permeation Sampson's theory, however, still remains the most popular

Burke² has recently reported a case of recurrent parathyroid adenoma occurring in a glandular graft In 1943 a parathyroid adenoma was completely excised and at operation a small fragment of the adenoma was transplanted



FIG 5—X-ray to show limb following treatment to recurrence after Rodger Anderson pins removed and limb encased in plaster

between the sternothyroid and sternohyoid muscles in an endeavour to avoid a hypoparathyroid state postoperatively Two years later the patient had a recurrence of hyperparathyroid symptoms and a benign parathyroid adenoma was removed from the sternothyroid muscle at the site of the graft In this case a small glandular fragment was intentionally implanted, whereas in the above case report it is indicated that the benign tumor cells were transferred by the instruments or gloves of the operator



FIG 6—Gross specimen from left iliac crest showing implantation tumor. It has been bisected to show the two halves of the implant occupying the lower half of the picture.

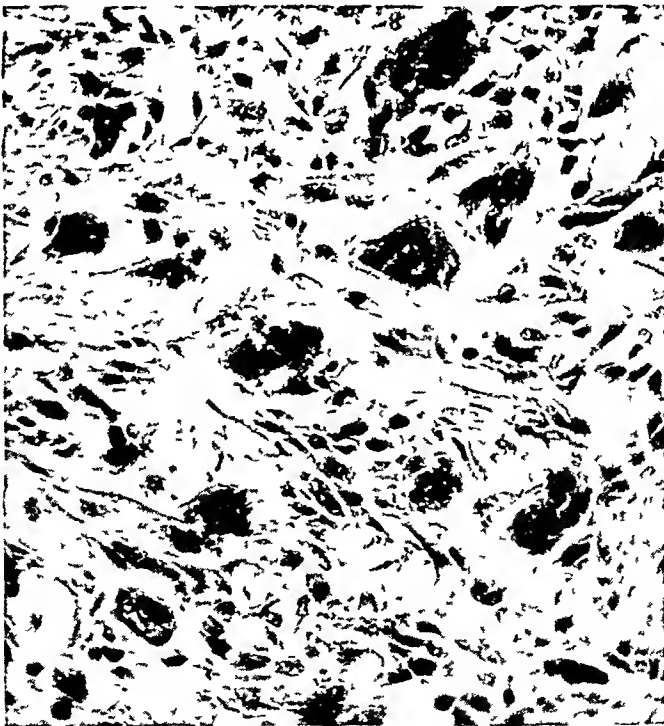


FIG 7—Microscopic appearance of the giant cell tumor implant which shows the same features as noted in the primary and the local recurrence.

SUMMARY

This case is reported to illustrate the operative transplantation of benign giant cell tumor of bone to a distant soft tissue site

The primary tumor originating in the upper end of the tibia and the local recurrence 9 months later showed a typical benign histological picture

The transplantation occurred in the soft tissue in the left iliac region at the site of previous operative interference and it revealed an identical histological picture

The authors wish to express their thanks to Dr R I Harris and Prof Wm Boyd for advice and criticism in the preparation of this paper

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PRIMARY CARCINOMA OF THE LIVER REPORT OF A CASE TREATED BY LOBECTOMY*

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THE LOW INCIDENCE of primary malignant tumors of the liver, the presumed difficulty of early diagnosis, as well as the hopeless prognosis usually accorded them, result in a paucity of patients receiving surgical therapy¹ Although a considerable number of surgical extirpations of tumor of the liver have been reported and summarized (Warvi)², the resection of primary carcinoma of the liver remains a relatively rare procedure, and lobectomy is even more uncommon³ At the Tumor Clinic, V A Hospital, Hines, Illinois, from 1934 to 1946, 36 cases of primary liver cell tumors were authenticated either at operation or post mortem examination Of these only one was resected

CASE REPORT

J D K, a 49 year old white cook of Greek origin, entered the V A Hospital, Hines, Illinois, July 7, 1942, complaining of a mass in the upper abdomen Save for a brother who had echinococcus disease of the liver, the family history was not significant The patient had travelled considerably but had arrived in the United States at the age of 17 and remained within its continental borders In Army service (1917-1919) diagnosis of minimal pulmonary tuberculosis and chronic pleurisy were established, but the patient had had no symptoms referable to the chest for the past twenty years The use of alcohol was limited during the past 34 years to a few glasses of dry *unrosmed* wine daily

Approximately one year before his admission, the patient complained of gaseous distention after meals which was relieved by alkaline powders and restriction of fats in his diet In January 1942 he noted a small pea-sized nodule high in the epigastrium, which remained in the midline when the patient was recumbent and shifted to the left when erect Just prior to his admission, he had two severe attacks of epigastric pain These occurred about two hours after meals and lasted 15 to 20 minutes, when they were relieved by the use of alkaline powders and a heat pad The patient stated that his weight had remained stationary for the past 10 years There was no history of nausea, vomiting or melena, and a systematic review of symptoms revealed no abnormalities The constant slow growth of the nontender lump in the abdomen had caused him to seek hospitalization, but he stoutly maintained that he did not feel sick

Examination showed a slight, poorly nourished, white male of 65 inches, weighing 107 pounds The abdomen was slightly scaphoid, soft, and nontender No scars or unusual surface veins were evident In the left upper quadrant there was a nontender, ballotable, round mass approximately 7 cm in diameter, which moved readily with respiration and showed no connection with the abdominal wall Neither the liver edge nor the spleen could be felt

Roentgen-ray study of the chest revealed an old, healed, calcified focus in the right subapical region, as well as pleural calcification at the right base A gastro-intestinal

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study disclosed no evidence of esophageal varices, but did show an extrinsic pressure defect of the greater curvature of the stomach with a secondary pressure defect of the greater curvature of the pylorus. There were no intrinsic gastric defects, but the duodenal cap showed slight irregularity of the left anterior border. Barium study of the colon revealed no abnormalities. Electrocardiogram showed a slurred QRS₃, a low T, and a decreased ST₁, ST₂. Fractional analysis of gastric contents showed a free acid varying from 0 to 8 and total acid from 16 to 26, with a trace of occult blood. No parasites were found in three examinations of the stool, with only a faint trace of blood

in one specimen. Urinalyses were negative. Red blood cells averaged 4,300,000 per cu mm with 85% hemoglobin and leukocytes varied between 12,000 and 10,000 per cu mm with a differential count averaging 50 polymorphonuclear cells, 48 lymphocytes, and 2 eosinophiles. Wasserman and Kahn tests were negative. Blood chlorides were 544 mg per 100 cu cm. Urea nitrogen 15.4 mg per 100 cu cm and sugar 76.9 mg per 100 cu cm. Icterus index varied from 9 to 12. Prothrombin time (Quick) was 100%. Tubercle bacilli were not found in any of the five sputum specimens.

A preoperative diagnosis of a hepatoma, left lobe of liver, or pancreatic cyst, was made and, on August 20, 1942, under gas-oxygen-ether anesthesia, operation was performed through a left upper paramedian incision. Careful examination was made of the entire peritoneal cavity and, with the exception of the liver, findings were normal. The liver showed a fine nodularity and was somewhat firmer than normal. A round, yellow-green, soft, partially cystic tumor, 6 cm in diameter, was noted in the left lobe of the liver. The tumor was elevated approximately 1.5 cm above the plane of the anterior surface. Upon aspiration, a small amount of necrotic debris was obtained. Immediate microscopic study by the pathologist showed cells indicative of hepatoma. No other lesions were found and the decision was made to resect the left lobe of the liver.

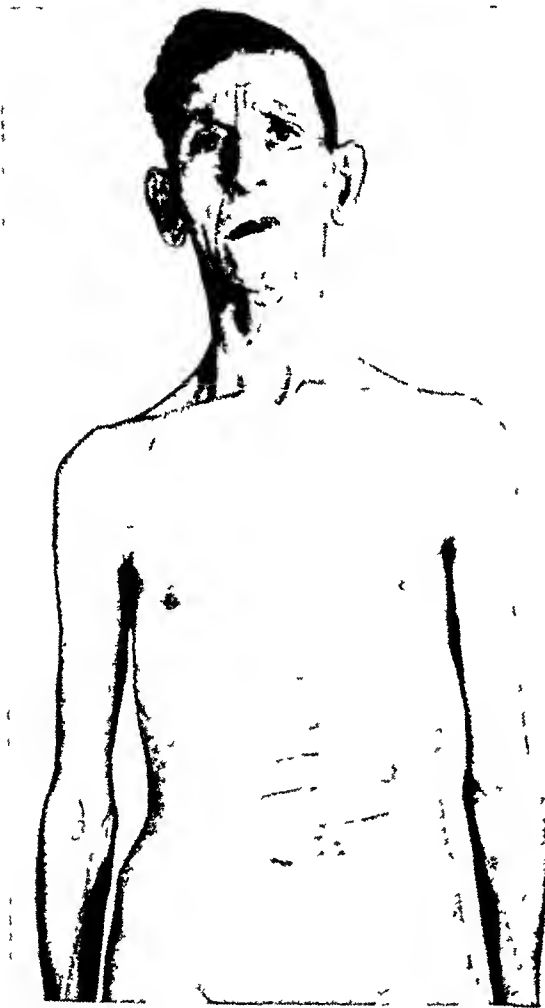


FIG 1—Photograph of the patient just prior to discharge. Preoperatively a mass was palpable in the left upper quadrant of the abdomen but could not be shown by a photograph.

The liver substance was suture-ligated with enveloping sutures along the umbilical incisure and the falciform ligament with No 0 chromic catgut on a long needle. Due to the cirrhosis of the liver, it was firmer than normal and retained the sutures well. The phrenic ligament was sectioned and the left lobe of the liver severed with the scalpel just to the left of the sutures. The raw surfaces were partly approximated with interrupted mattress sutures. A free omental graft was then obtained and fastened over the resected end of the liver with No 00 catgut sutures. No bleeding was noted and the abdominal wall was sutured in layers. 500 cc of whole blood and 1,000 cc of 5% glucose were given intravenously during the operation. The patient's condition was excellent throughout the entire procedure.

Pathologic report by Dr William McNamara was as follows "Specimen is the left lobe of the liver, which measures approximately 15x8x6 cm, containing an encapsulated tumor mass in the central portion which measures 5 cm in diameter. The mass on cross section is lobulated and has a grayish-greenish color, it shows some evidence of degeneration. The liver proper is hobnail in type. Microsection of tumor discloses cords of cells which resemble the liver cords quite closely. The nuclei, however, are quite hyperchromatic and show some variations in size. The cytoplasm for the most part is granular to fairly clear. There is some variation in size of the cells and an occasional mitotic figure is noted. Many of the columns of cells are surrounded by a blood space. There is very little or practically no fibrous stroma. The lesion is quite typically of a liver cell origin and imitates the liver quite closely. Microsection of the liver also discloses an early portal cirrhosis.

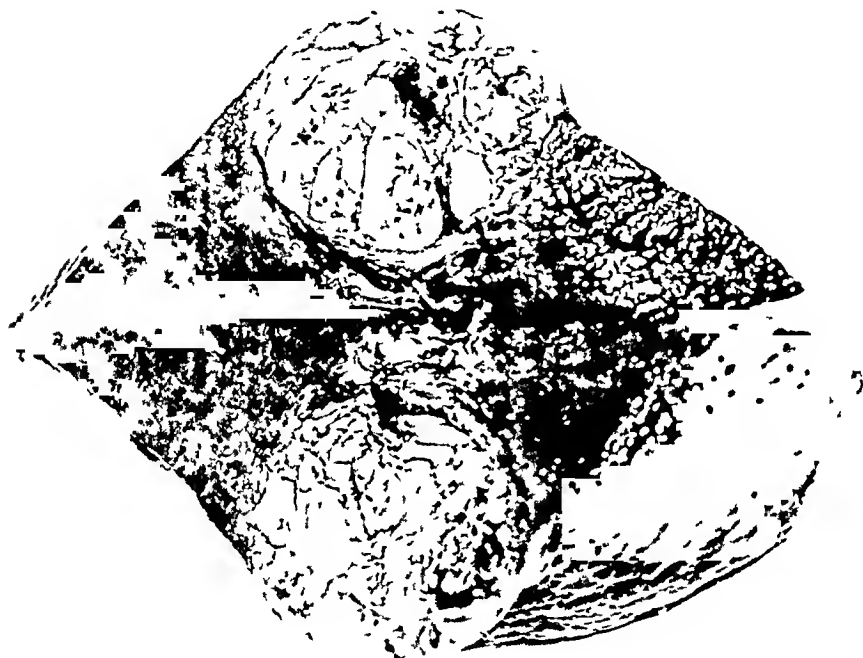


FIG 2—Section through the anterior surface of the left lobe of the liver and directly through the tumor. Note the nodularity of the surface of the liver.

with some increase in connective tissue and quite an extensive round cell infiltration throughout the portal areas. There is some reduplication of the bile ducts. The liver cells proper are divided into lobules by the connective tissue and show some evidence of hyperplasia. All the cells are mildly granular.

DIAGNOSES Solitary hepatoma, liver
Cirrhosis, portal, early"

Convalescence was slow but uneventful. Blood chemistry postoperatively showed a normal urea nitrogen of 14 mg per 100 cc, cholesterol of 200 mg per 100 cu cm, albumin 3.9 Gm, and globulin 2.4 Gm, with a total protein of 6.3 Gm per 100 cu cm. Takata-Ara test showed a strong positive reaction. The patient was discharged on September 28th, symptom-free.

Follow up in April 1943 revealed that, while the patient had gained ten pounds in weight, he tired easily and had occasional pains in the left upper abdomen. Examination revealed a postoperative hernia in the abdominal scar, which was well controlled by means of an elastic support. No abdominal masses were palpable. In October of the same year, the patient reported a dull left upper quadrant ache. He was seen again in

April 1944, but his condition remained unchanged. Between the time of this follow up and his final admission, July 6th, the patient developed edema of both lower extremities, an increase in girth of the abdomen, a dragging sensation in the lower abdomen, infrequent but fairly sharp left upper abdominal pain, progressive enlargement of the hernial protrusion, as well as weight loss, weakness and yellowing of the skin.

Examination revealed a chronically ill, frankly icteric, weak, poorly nourished male, in no acute distress. His height was 5 feet 5 inches, his weight 115 pounds. Blood pressure was 95/60. The pertinent physical findings were limited to the abdomen. The large upper left pararectus incision was well healed, but there was a diastasis of the underlying rectus musculature. A large, firm, freely movable, midepigastriac and right upper quadrant mass was palpable, presumably liver, which could be freely ballotted within the abdominal cavity. There was also present a moderate amount of ascites. The patient's icterus index varied from 30 to 60, his cephalin flocculation test was reported as plus 3, his van den Bergh revealed a delayed direct reaction, urine was reported as dark amber, with a specific gravity of 1.024, showing no formed or cellular elements. The serum protein was reported as 6.3 mg per 100 cu cm, albumin, 3.4 Gram per 100 cu cm, and globulin, 2.9 Gm per 100 cu cm. Blood cholesterol was reported as 225 with 60% esters. Bromsulfalein test showed 80% retention for one half hour and 70% for one hour. Stools showed stercobilin and no evidence of occult blood. Despite supportive therapy, the patient developed progressive abdominal distention and ascites and retrogressed steadily. He died July 29, 1944, 23 months after lobectomy.

At autopsy no evidence of extrahepatic metastases was found. Both lungs were waterlogged, spleen showed congestion, kidneys were edematous and the adrenals showed some cortical atrophy. Dr. McNamara's findings in the abdomen and liver follow:

"In the anterior abdominal wall there was practically no subcutaneous fat with a separation of the muscles and fascia in the upper abdomen and herniation under the skin. About 2500 cc of green fluid was found in the peritoneal sac. Left side of the liver was covered by dense adhesions where the left lobe of the liver was resected and the stomach was adherent to the area. No lymph gland enlargement was found. The liver weighed 1700 Gm, was green and nodular, and showed hobnail cirrhosis. In the liver substance there were four large nodules, softer than the remainder of the liver, circumscribed by connective tissue, gray-brown with a greenish cast. The largest measured 6 cm in diameter. These were hepatomas similar in appearance to the large hepatoma of the left lobe of the liver which was resected surgically. The left end of the liver from which the left lobe was removed was covered with scar and there was no evidence of recurrence at this site. The esophagus and stomach showed many large dilated veins in the walls but no evidence of rupture."

The histopathology of the tumor was unchanged from the previous report.

Although there was no gross evidence of metastasis in the right lobe at the time of operation, it is our belief that microscopic deposits were present. This has been exemplified in two recent personal cases with lesions apparently located in the left lobe. Biopsies of apparently grossly normal tissue showed microscopic evidences of carcinomatous infiltration. It is, nevertheless, possible that in this case the later growths were separate tumors of multicentric origin in a cirrhotic liver.

DISCUSSION

Biopsy is imperative in the diagnosis of liver tumors, and this is best performed during the course of exploratory laparotomy. In concurrence with the opinion of the majority of observers, we have noted but a very few temporary arrests following the present day methods of irradiation of liver tumors, and have been impressed by the many severe and harmful reactions^{4, 5}. Although peritoneoscopy with biopsy has been advocated, it is our opinion that an exploratory laparotomy adds but slightly more trauma to the properly prepared patient, and aids greatly in the decision of resectability. Every case

FIG 3

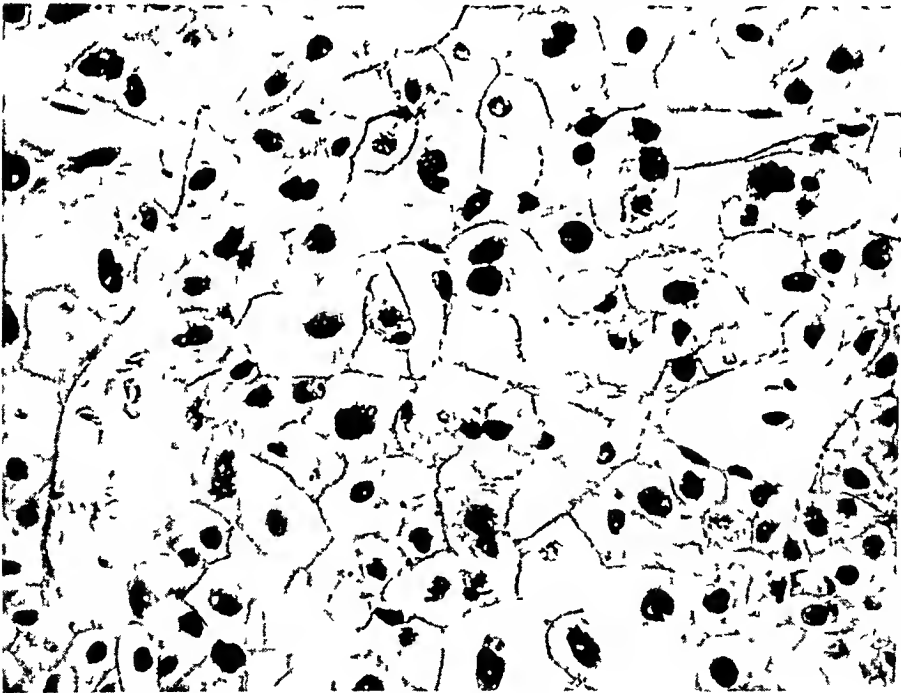


FIG 4

FIG 3—Low power photomicrograph (100x) of tumor showing expansive growth in all directions, central necrosis and fibrous stroma. Note nuclear variability.

FIG 4—High power photomicrograph (450x) of field of Fig 3, showing irregular nuclear outlines, hyperchromatism, and mitotic figures. Note resemblance to liver cells and relation to blood vessels.

of suspected primary tumor of the liver should be explored, and surgical resection should be attempted in all localized liver tumors without evidence of involvement of adjacent organs or too much of the liver itself. When the left lobe is involved, the procedure of choice is lobectomy, to allow a maximal excision of tumor, permit suturing through normal tissue, take advantage of the possible physiologic line of cleavage and utilize the falciform ligament as a hemostatic covering for the raw surface of the right lobe, as brought out by Pickrell and Clay³

It has been shown that the liver is a symmetrical organ with independent vascular supply to each lobe, with abundant anastomoses insuring adequate circulation if a section is cut off from its normal blood supply,⁶ and with rapid regeneration after removal of its substance^{7, 8}

The control of hemorrhage has been the greatest consideration in surgical resection of liver tumors, and several methods of hemostasis have been devised. The majority of patients with hepatoma have a prior cirrhosis which aids the retention of sutures. With care, and with the use of rather thick sutures and smooth, non-cutting needles, the normal liver tissue can be successfully resected and sutured, as we have found when dealing with other tumors, for example, carcinoma of the stomach, with direct extension into a limited area of liver. The advent of new hemostatics^{9, 10, 11, 12}, such as fibrin foam, absorbable cellulose, synthetic adhesives^{9, 10, 11, 12}, and new suture materials, such as flat tantalum bands, should lead to more frequent extensive operations for neoplasms of the liver.

SUMMARY

A case of primary carcinoma of the left lobe of the liver was subjected to lobectomy successfully. At autopsy, 23 months later, only intrahepatic tumors were found.

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PSEUDOEMBOLIC PHLEBITIS WITH LIGATION OF THE INFERIOR VENA CAVA

A Case Report

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AND

H R HAWTHORNE, M D

PHILADELPHIA

THE CASE HERE REPORTED represents an uncommon type of thrombophlebitis which although well recognized and described by the French, has received little attention in the American literature. It is of interest because of the mode of onset, the complete obstruction of the inferior vena cava proximal to the point of surgical approach and the end result following inferior caval ligation.

Case Report O K, male, age 56, admitted to The Graduate Hospital 7/15/46, having been transferred from another hospital where he had been under treatment since 7/11/46. His chief complaint on admission was painful, swollen legs. His family history was negative. His past medical history revealed pneumonia, complicated by myocardial infarction in March, 1946, and an acute right subdeltoid bursitis in June, 1946. He had made a satisfactory recovery from both conditions.

His present illness began on July 7, 1946, when he first noticed vague aches and pains in the region of his right groin. These pains continued and became slightly more marked during the following two days. On the second day after onset (July 9) the patient was seized with excruciating pain in the right leg, and a dark congested color developed. He became so weak that he fell to the floor. At this time, according to the referring physician, the limb was very ecchymotic, swollen, cold and no pulsations could be felt in the femoral or dorsalis pedis arteries. His leg was very tender in the region of the ham string muscles and the muscles were spastic. The reflexes were decreased and the pain was so severe that opiates were required. At this time, his temperature was elevated to 99.4°. During the next two days, the severe pain in the right leg continued and the swelling increased very rapidly. On July 11 (the day of admission to the other hospital), the patient had a similar, but less severe attack of pain in the left groin and the left leg began to be involved in a similar process. During this time his temperature averaged about 101°.

A summary of the patient's clinical course during his stay in the other hospital revealed the following. Physical examination on July 12, was negative except for the following findings: "The abdomen is moderately distended. There is a little resistance in both lower quadrants. The entire right thigh is swollen from Poupart's ligament to the knee. There is some tenderness in the left groin, where one feels several enlarged lymph nodes. There is distinct tenderness in the right groin. The swelling described above is general and fails to localize. There is no evidence of venous engorgement and the circulation is apparently intact as the blood vessels can be satisfactorily palpated."

Laboratory findings were as follows:

7/12/46 *Urine*—Alkaline, clear, specific gravity 1.024, albumin 3 plus, sugar negative. Microscopy reveals a moderate number of hyaline casts and an occasional coarsely granular cast, occasional leukocytes and a few squamous epithelial cells.

Blood count—Hgb 86%, R B C 4,110,000, W B C 22,500, segmented 77%, immature 6%, lymphocytes 9%, monocytes 8%.

Blood sugar—40 mg per 100 cc of blood.

Prothrombin time—Last night, July 11, 35 seconds. This A M 1 minute, 5 seconds.

7/13/47 *Platelet count*—R B C 4,470,000, platelets 150,000 W B C and Differential W B C 23,050, segmented 81%, Prothrombin time 3 minutes

7/12/46 *Electrocardiographic report*—Left axial deviation QRS2 slurred

Conclusions—Myocardial damage Left hypertrophy

Dicumarol therapy was instituted on the evening of July 11th The following schedule of dicumarol therapy had been given before admission to the Graduate Hospital

7/11/46 Dicumarol 200 mg

12 " 400 "

13 " 400 "

14 " 200 "

15 " 200 "

In spite of a rapid and extreme dicumarol response, measured by a prothrombin time of one minute, five seconds on July 12th, and three minutes on July 13th, the patient's condition, as evidenced by increasing edema, rapidly deteriorated

Physical examination after admission to the Graduate Hospital on July 15, 1946, was negative except for findings in the abdomen and lower extremities At this time there was marked edema of both lower extremities and of the abdominal wall up to the level of the umbilicus Acute swelling was also noted in the region of the left knee joint The skin over this area was reddened and the local temperature increased Marked tenderness was present throughout both lower extremities, particularly in the region of the inguinal ligaments Severe pain was produced by the slightest attempts at passive motion of the lower extremities

On July 16th, the following note was made by Dr Lisker, of the department of peripheral-vascular disease "The history suggests an occlusion of the pelvic veins, probably at the level of the common iliacs or the inferior vena cava The occurrence of bilateral effusions in both knee joints suggests an infection as the cause of the phlebotrombosis I recommend ligation of the inferior vena cava with aspiration of any clots found above or below this level The prothrombin time, while delayed beyond anything I have ever seen, cannot be considered a contraindication to immediate surgical interference, since this is an emergency The condition of the blood (prothrombin time) can be corrected with whole blood or plasma preoperatively There is no evidence of interference with the arterial circulation"

Laboratory work at this time revealed the urine to be entirely normal R B C 3,790,000, Hgb 63%, Leucocytes 13,000 Neutrophils 85%, Eosinophils 3%, Monocytes 2%, Lymphocytes 10% Prothrombin time 9 minutes Clotting time 5 minutes 15 seconds Wasserman negative B U N 19 mg Total protein 6.48 Albumin 3.98, Globulin 2.50

Roentgenogram of the chest 7/16/46

The examination of the chest shows the bony thorax and diaphragms to be negative The heart shows moderate left ventricular enlargement and aneurysmal dilatation of the ascending aorta The arch and descending aorta show only slight widening A slight haziness is noted over the right dome of the diaphragm which might be due to either a resolving pneumonitis or a shallow respiratory phase

Operation—The patient was typed, cross matched, and a transfusion was started immediately The patient was then taken to the operating room and under spinal anesthesia (procaine) a transverse incision was made 2 cm above the right anterior superior spine of the ilium The peritoneum was carefully displaced forward with due regard to the right ureter and spermatic vessels and the inferior vena cava was exposed The plexus of the lumbar veins lying in the groove between the ilio-psoas muscle and the inferior vena cava was tremendously dilated This caused considerable difficulty in exposing the vena cava and was the source of some troublesome bleeding The inferior vena cava was carefully separated from the aorta and surrounding structures for a dis-

tance of $1\frac{1}{2}$ cm. Two No. 8 silk untied ligatures were placed about the inferior vena cava about 2 cm apart. The inferior vena cava was then opened between the two ligatures and free bleeding occurred from the distal end, but no bleeding occurred from the proximal end. The ligature distal to the opening in the inferior vena cava was then tied securely. Suction was applied within the lumen of the vena cava proximal to the point of opening and a large mass of blood clot was removed from a point at least seven or eight cm above the opening in the inferior vena cava. The clot removed consisted of a large white organizing thrombus roughly 2 cm in diameter, with red thrombi on its surface. The site of obstruction was very close to the point of entrance of the renal veins. Following this, free bleeding occurred from the proximal end of the vena cava and the proximal ligature was immediately tied. During this procedure the vena cava had been almost completely divided. Both ends were then secured by transfixion ligatures of No. 8 silk. The wound was closed leaving a Penrose drain in the retroperineal space. 500 cc of blood and 900 cc of plasma were given during the operative procedure. The patient was returned to his bed in good condition.

Postoperative course—The patient returned from the operating room in good condition. The foot of the bed was elevated and Ace bandages were applied to both legs from toes to groins. No change in the amount of edema was noted for five days after operation.

The blood urea nitrogen which was 19 mg on the day of operation had risen to 34 mg on the following day, but returned to 18 mg within two days.

The prothrombin time fell from nine minutes on the day of operation to one minute on the following day, but remained at this level, in spite of transfusion and plasma administration, until the sixth postoperative day, when it was 22 seconds. It became normal—13 seconds—on the eleventh postoperative day and the coagulation time was two minutes and fifteen seconds.

During the evening of the fifth postoperative day, there was free bleeding from the operative wound. This was controlled by packing the wound, large doses of Vitamin K intravenously and transfusions of whole blood.

Immediately after operation (2 days) paralysis of the left radial nerve was noted. This was thought to be the result of the patient's position on the operating table. This cleared during the hospital stay.

By the thirteenth postoperative day the edema of the legs had almost disappeared. The patient was allowed out of bed.

He was discharged twenty-three days after operation with supporting bandages on both legs. Only moderate ankle edema was present at this time.

COMMENT

Pseudoembolic phlebitis or the "Blue Phlebitis of Giegore" is an uncommon type of venous occlusion characterized at the onset by a degree of reflex arterial spasm so great as to suggest embolism of a major artery. The onset is dramatically sudden with severe pain and collapse. The limb becomes cyanosed and chilled and there is absence of arterial pulsations. This is followed by the rapid onset of edema.

It is worthy of note that of the four cardinal symptoms and physical signs, namely pain, cyanosis, chilling and edema, only one, edema is of venous origin. The remaining three are due to an extreme degree of concomitant arterial spasm. The blue discoloration, previously attributed to venous obstruction is correctly described by Giegore as being due to asphyxiation incident to an inadequate supply of arterial blood. Numerous cases have been

reported in which this arterial spasm was so severe and prolonged as to lead to gangrene of the extremity without actual occlusion of the artery

An understanding of the mechanism involved in this type of phlebotic disease emphasizes the role of sympathetic block in its treatment. The prognosis at best is extremely grave. Early recognition with appropriate use of sympathetic block may well be the means of saving the limb or even the life of the patient. The arterial phase, as in the case here reported may be relatively short and be followed by the changes more universally recognized as due to primary disease of the venous system.

This case did not come under our observation until after the period of intense arterial spasm. It had however progressed rapidly to the point of inferior caval occlusion in spite of more than adequate anticoagulant therapy. Although no embolic phenomena had as yet occurred, it was decided after consultation with the department of peripheral vascular diseases that immediate surgery was indicated. The patient seemed to us to be in great danger of one of two fatal complications. A massive pulmonary embolus might occur at any moment, or the thrombotic process might reach and occlude both renal veins.

It is interesting to note that this patient had received adequate anticoagulant therapy in another hospital during the four days previous to his admission to the Graduate Hospital. On the morning of operation his prothrombintime was nine minutes, and the coagulation time, five minutes and fifteen seconds. In spite of this, the thrombotic process had progressed rapidly to a critical point. Attempts to control this by blood and plasma transfusions, did not bring a satisfactory response until six days after operation. Although there was a marked prolongation of prothrombin time to nine minutes, hemorrhage was not a serious problem at operation. A moderate amount of bleeding from the wound, which occurred on the fifth postoperative day, was satisfactorily controlled by packing in the wound and transfusion.

We should also like to refer further to the technical difficulties involved in this particular case. The plexus of lumbar veins, lying between the mesial border of the iliopsoas muscle and the inferior vena cava, was tremendously dilated because the point of complete obstruction was seven or eight centimeters proximal to the area of surgical approach. Isolation of the inferior vena cava in this circumstance was a difficult and tedious dissection that required some enlargement of the original incision.

When the vena cava was opened a moderate amount of bleeding occurred from the distal end, indicating that both common iliac veins were not completely obstructed. No bleeding occurred from the vena cava proximal to the point of surgical approach. The large thrombus previously described, was removed from the inferior vena cava by suction at least seven centimeters above this point following which profuse bleeding occurred. The proximity of the process to the renal veins is at least suggested by the rise in blood urea

nitrogen to 34 mg on the day following operation. Fortunately, this returned to 18 mg in two days.

The clinical course following operation is also of interest. The ligation was performed on July 16, 1946, and the patient was able to leave the hospital on August 8, 1946, with a moderate amount of edema of the lower extremities. Examination in November, 1946, in the peripheral vascular department, revealed moderate edema below the knees in both legs. The patient was able to be about normally with the aid of supportive bandages to both limbs. By January, 1947, he had only slight ankle edema, little evidence of dilation of the superficial veins and was able to resume his usual occupation as a railroad engineer.

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CHOLEDOCHO-DUODENO-JEJUNAL INTUBATION FOR FEEDING FOLLOWING CHOLEDOCHOSTOMY

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VERY OFTEN FOLLOWING CHOLECYSTECTOMY and much more often following choledochostomy patients are bothered for days by vomiting. Moreover these patients are generally obese, making venoclysis difficult. The following method of feeding is presented in order to simplify the postoperative care of these patients.

A Number 6 French ureteral catheter with a fairly supple stylet in place is passed through a number of 16 French, or larger, T-tube, leaving only a centimeter of the catheter visible above the end of the long limb of the T-tube. With the common duct open, the distal end of the catheter is then threaded through the common duct, through the ampulla of Vater into the duodenum. After the direction of the catheter is down and the catheter has passed to the junction of the second and third portion of the duodenum, the stylet is withdrawn so that the bowel will not be punctured. The catheter is then passed around into the jejunum. The medial limb of the T-tube passes on into the common duct with the catheter, and if desired the end of the T-tube will easily follow the catheter through the ampulla of Vater into the duodenum. The lateral limb of the T-tube is then put in place and the common duct sutured. The remainder of the operation is carried out as usual.

After the wound is closed and dressed, a needle hole is made about four centimeters from the end of the protruding limb of the T-tube, and, by stretching this part of the T-tube over the end of the catheter, the open end of the catheter may be brought out through this hole and the hole closed with rubber cement and a glove patch. This aids in keeping bile from draining onto the dressings. Here care must be used not to dislodge the portion of the T-tube in the common duct. A 19-gauge needle is then passed into the open end of the catheter, anchored with adhesive, and a regular clysis outfit attached to the needle. Fluids may then be given as needed, preferably continuously, by regulating the number of drops per minute so that the desired fluid will go in over a 24-hour period. Minerals, vitamins, proteins, and soluble drugs may be given through the catheter. Amigen has been used for the protein in this group of cases because it would not clog the catheter and because it was available. Giving 2,000 cc of amigen daily over a three or four day period will sometimes cause a diarrhea which can be controlled with paregoric. After a day's rest, the amigen may be started again if needed. The bile collected by way of the tube may be strained through fine gauze, diluted with saline, and given back through the ureteral catheter.

Case 1 Mrs. M. was admitted with obstructive jaundice. The common duct was explored and a T-tube put in place. The follow up choledochogram showed a persistent filling defect in the common duct, necessitating further exploration. A ureteral catheter

was passed down the sinus tract into the common duct to facilitate identification of the common duct. The catheter passed easily through the ampulla of Vater into the duodenum and on to the jejunum as verified by roentgen-ray. With the catheter in place the common duct was easily identified and opened. As a stone could not be found, the duodenum was opened and by means of the catheter the ampulla of Vater was easily identified and incised. Upon completion of the exploration a T-tube was sutured into the common duct beside the ureteral catheter and the end of the catheter and T-tube brought out through a stab wound in the flank. Following the original operation the patient had vomited almost continuously and the fact that she had very bad veins

made it difficult to feed her properly, so the catheter was left in as an aid in feeding her. She also had Wangersteen's suction in place to protect the wound in the duodenum. She was successfully fed through the catheter for 15 days following the second operation, after which time the catheter and T-tube were removed and she was able to take and retain nourishment by mouth. On the second postoperative day she developed a pneumonia which was treated successfully by giving sodium sulfadiazine through the ureteral catheter. Acidosis was combated by giving one-sixth molar Sodium R-Lactate solution through the catheter. She received 2,000 cc amigen daily through the catheter and on the fourth postoperative day developed a diarrhea which was controlled with paregoric given through the tube. Amigen was started the following day and she was not again troubled with diarrhea.

Case 2 Mrs. P. On the sixth post-partum day it became necessary to do a cholecystostomy for removal of a common duct stone because of progressive obstructive jaundice. Following removal of the common duct stone, a number 5 French ureteral catheter was passed through the T-tube and inserted through the common duct as

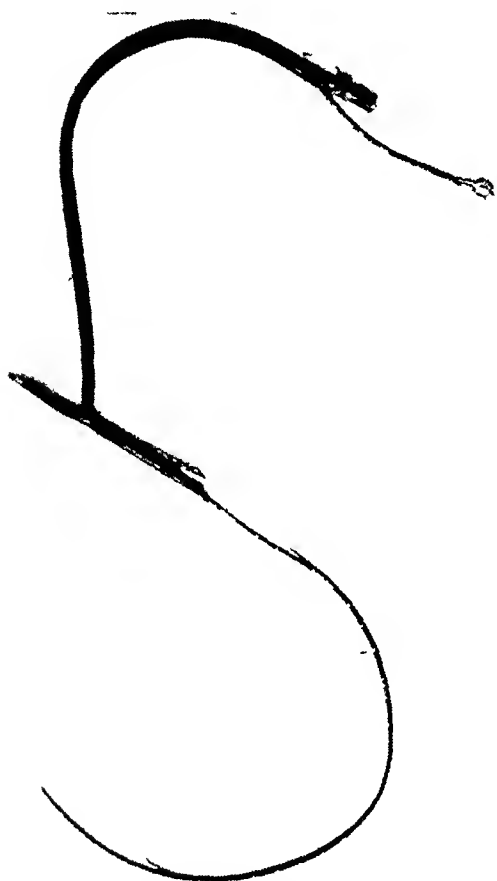


FIG 1—Photograph of T-tube with ureteral catheter following removal from Case 5

previously described. Besides 10% glucose, minerals, and vitamins, she received 2,000 cc of amigen daily through the ureteral catheter. Diarrhea developed on the third postoperative day, this was controlled with paregoric given through the catheter. Following this only enough amigen was given to keep the plasma proteins within normal limits. The patient started taking food by mouth on the fifth postoperative day and on the tenth postoperative day the T-tube and catheter were removed. On the sixteenth postoperative day she was discharged from the hospital with a completely healed sinus tract.

Case 3 Mrs. G., a 77-year-old white woman, at operation was found to have a small hobnail liver. The cirrhosis was thought to have been caused by a large non-obstructive common duct stone. After the removal of a portion of the jejunum and the completion of an aseptic end-to-end anastomosis, the stone was removed from the common duct. A T-tube with the ureteral catheter was put in place as described above and the common duct closed. On the third postoperative day she developed an oliguria with some edema of the dependent tissues. Her plasma protein was found to be 5.04 Gm. The low protein was thought to be due to faulty liver metabolism. She was given 600 cc of blood plasma daily for four days, bringing her plasma protein up to 6.8 Gm. On

the fifth postoperative day her output of urine was normal. At the time the blood plasma was started, 10% glucose was given through the ureteral catheter, as it was thought that there would be some absorption of fluids through the jejunum proximal to the site of anastomosis. For two days the fluid aspirated through the Wangensteen suction was equal to that given through the ureteral catheter. The stoma then began



FIG 2—Choleodochogram of Case 2. Syringe is end of T-Tube and needle is in end of catheter.

to function and the Wangensteen suction was discontinued. On the fifth day of intravenous plasma protein she developed a rather severe anaphylactic reaction. Her plasma protein level was thereafter maintained by amigen given through the ureteral catheter, as she still had a tendency to vomit any food and most oral medication. She did, however, retain most of the choline and methionine given by mouth. No attempt was made to give this through the catheter. Her plasma protein on the fourteenth postoperative day was

67 and she was retaining some food given by mouth. It was interesting that when there was increased jejunal intraluminal pressure, the flow of fluid through the catheter became slower and at times stopped with escape of gas through the catheter as demonstrated by the flow of bubbles up through the infusion bottle. The T-tube and catheter were removed on the fourteenth postoperative day, and on the following day the patient got out of bed.

Case 4 Miss W. was admitted with progressive obstructive jaundice with a sub-acute cholecystitis. Following choledochostomy the T-tube with a number 6 French ureteral type of catheter was put in place. Fluids were started immediately through the catheter on the return of the patient to her bed. Because of a low blood pressure immediately following operation 1000 cc. of fluid was given intravenously, and other than this no other intravenous fluids were given postoperatively. On the third postoperative day the bile flowing through the T-tube had assumed a normal color and it was collected, strained, and given back to her through the ureteral catheter. She was gotten out of bed on the fourth postoperative day and on the fifth postoperative day was taking fluids and food by mouth. On the sixth postoperative day fluids, proteins, minerals, vitamins, and bile through the ureteral catheter were discontinued. Her convalescence was uneventful.

Case 5 Miss L. had a cholecystectomy for stones and exploration of the common duct showed it to contain much sand-like material. A ureteral type catheter was used to irrigate the larger hepatic ducts and common duct until it was thought all these particles had been removed. Following this a T-tube with a number 6 French ureteral catheter was put in place and the common duct sutured over the T-tube. Fluids, minerals, vitamins, and proteins were started through the ureteral catheter immediately on her return to bed. Intravenous fluids were not needed or used postoperatively in this case. On the second postoperative day she was taking fluids and food by mouth. On the fifth postoperative day she was taking sufficient fluids and food by mouth and fluids were no longer given through the ureteral catheter. Her convalescence was uneventful.

Case 1 has been followed for eleven months and Case 2 for five months and both are in good health with no demonstrable ill effects from the use of the catheter. The last three cases have been done in the last month and to date there are no demonstrable ill effects from the use of the catheter. In the first three cases a number of 5 French ureteral radio-opaque catheter was used, in the last two cases a number 6 French radio-opaque catheter. Radio-opaque catheters were used so that their position could be checked by roentgen-ray. In one of the cases using a number 5 French catheter (this catheter had been previously used) the flow of amigen at times was not so rapid as desired, and for that reason number 6 French catheters were used in the last two cases. Other liquid proteins can probably be administered by this method.

SUMMARY

A simplified method for adequate feeding of patients following choledochostomy by choledochoduodeno-jejunal intubation through the use of a ureteral catheter has been presented. It has also been demonstrated that no ill effects nor delay in oral feeding is caused by this method.

CARCINOMA OF THE PREMENOPAUSAL BREAST

Endocrine Influence Suggested Clinically in 31 Cases

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FOR MANY DECADES efforts have been made to associate features of ovarian functions with adenocarcinoma of the breast. In animal experimental work many authors have shown ovarian factors to play major roles in the onset and development of breast neoplasia, but no definite correlation has ever been proven between their findings and human cases^{1, 2}. The symbiotic effects of estrogenic substances on animal strain susceptibility suggests some correlation in cases such as those to be reported.

Clinically, a reverse ovarian effect has been shown by the reported palliation from oophorectomy in breast malignancy. That this effect has been greatest in premenopausal cases would be expected. Actual carcinogenic effect by administration of estrogens has been suggested only in reports of breast malignancy occurring subsequent to ovarian therapy^{3, 4, 5, 6}. Such reported cases have been few in comparison to the widespread administration of these endocrines, and generally are imbued with the idea of coincidence. This is not justified if susceptibility to breast malignancy is an individual factor in each patient, as is shown to be the case with animal strains. On such a basis, the variable effect of estrogen administration would be expected. The following case studied at this hospital suggested an association between ovarian factors and adenocarcinoma of the breast.

Case 1, NK, EFSCH No 3565 *History*—This 44-year-old white woman was admitted to the hospital on December 8, 1941, stating that 6 months previously she consulted a local physician because of beginning irregularity and oligomenorrhea, with severe nervous tension. There were no signs or symptoms of pathologic alterations in the breast at that time. She was given 20,000 I U of theelin over a 3 weeks' period. In August, both breasts simultaneously became hard and painful and the following September she was given 75,000 more I U of theelin (15,000 weekly). At that time, the breasts showed diffuse tender nodularity. In November, small subcutaneous nodules appeared throughout both breasts and the patient was sent to this hospital with a diagnosis of probable cystic mastitis.

Admission Examination—The patient was a fairly well-developed, well-nourished female. Both breasts were small, firmly nodular, with the nipples retracted and holding their position when the patient was recumbent. Numerous small rounded subcutaneous nodules were noted in the skin about the breasts (Fig 1). The axillary nodes were bilaterally palpable and firm, but small. The liver edge extended 5 fingerbreadths below the costal margin. The pelvic examination was not remarkable. Roentgenologic studies revealed widespread osteolytic metastasis involving ribs, vertebrae, pelvis, and cranium. Biopsy of the breasts was diagnosed as carcinoma, possibly of acinar origin (Fig 2).

Subsequent Course—The patient was discharged from the hospital on December 12, 1941 with a hopeless prognosis. On February 13, 1942 she returned to the clinic with jaundice of four week's duration and an icteric index of 40. An attempt to perform a palliative cholecystojejunostomy failed because of metastatic spread along the biliary tree, including extensive involvement of the liver and gall bladder. Liver biopsy revealed

CARCINOMA OF THE PREMENOPAUSAL BREAST

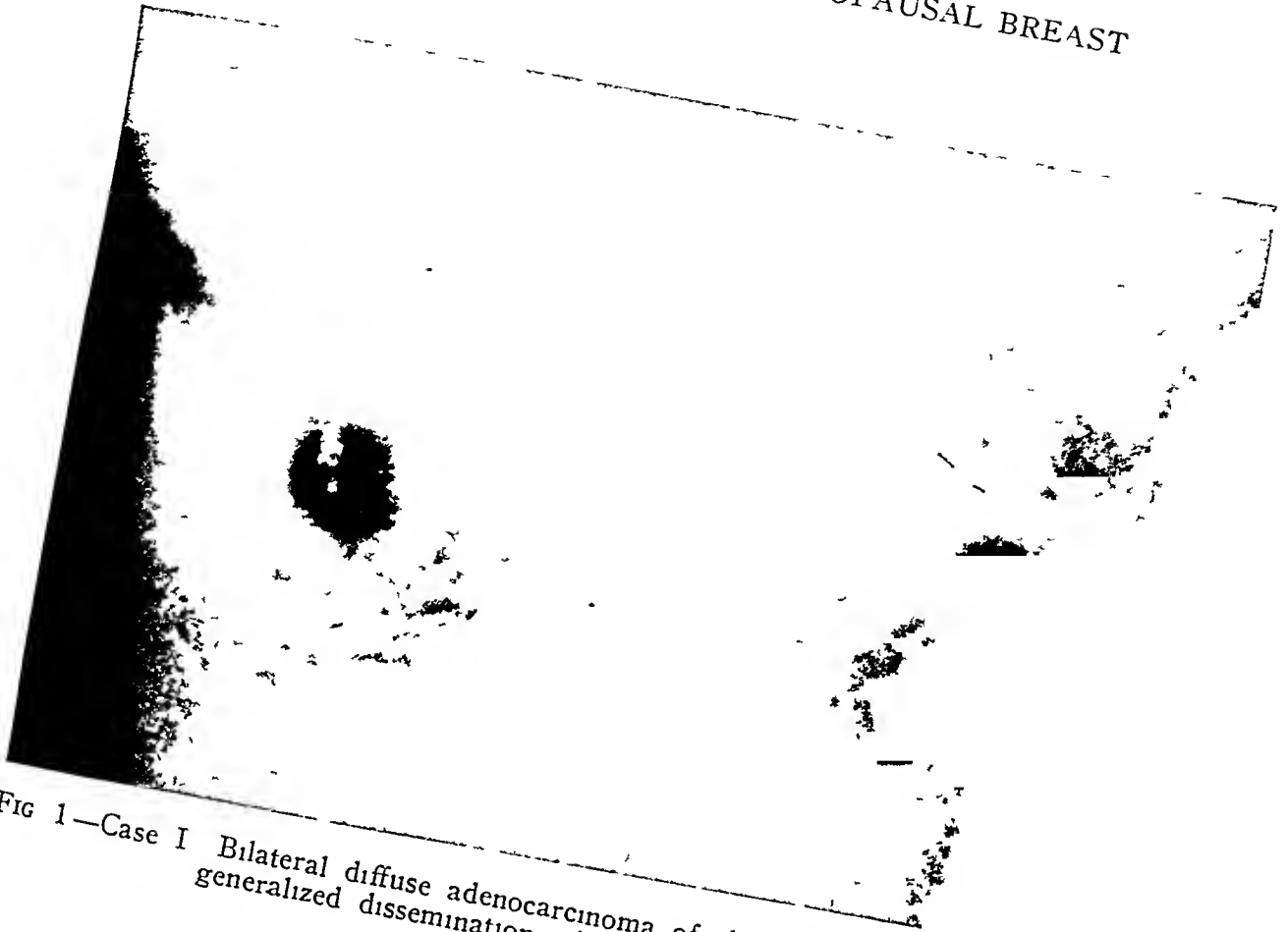


FIG 1—Case I Bilateral diffuse adenocarcinoma of the premenopausal breast with generalized dissemination (Admission photograph)

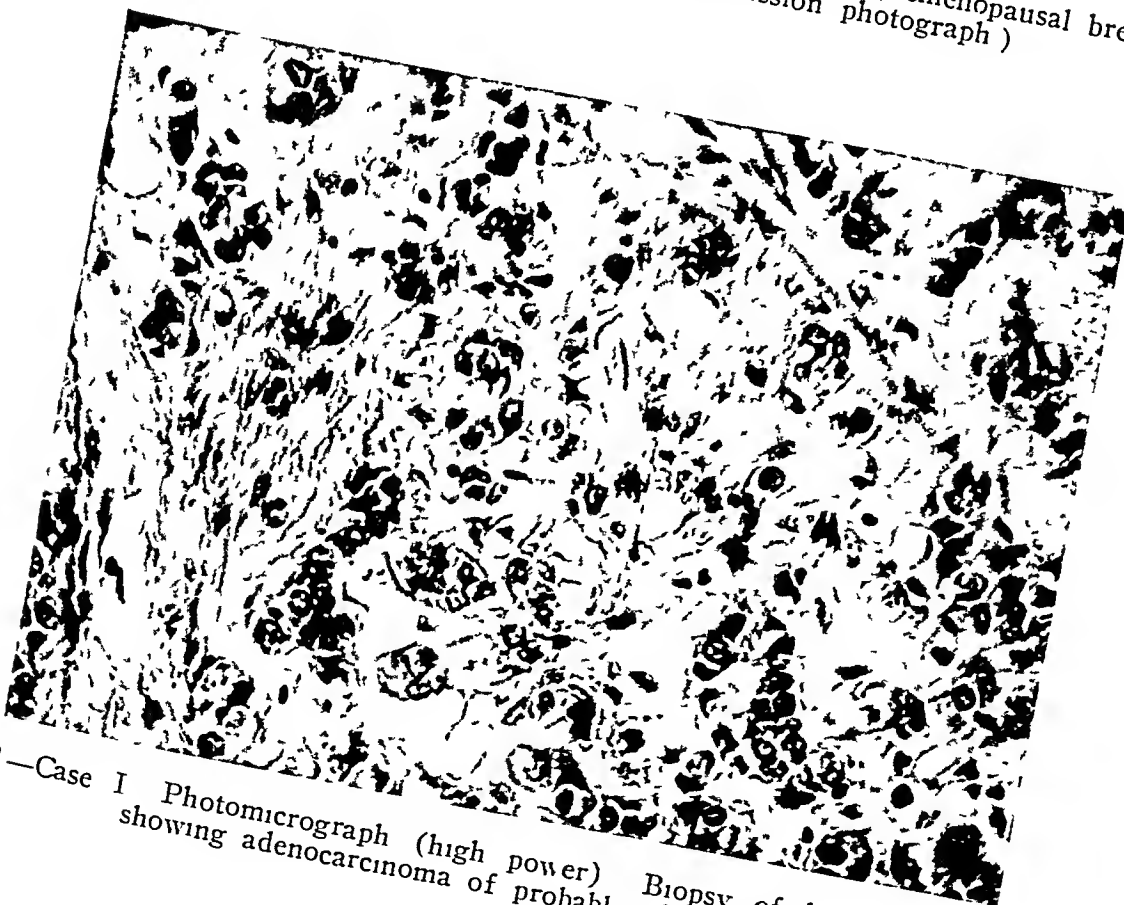


FIG 2—Case I Photomicrograph (high power) Biopsy of breast parenchyma, showing adenocarcinoma of probable alveolar origin

extensive replacement by tumor tissue. Limited exploration suggested a generalized peritoneal spread of the tumor. The patient recovered from the laparotomy and returned home as a terminal case.

To the amazement of the Staff, she returned for a clinical checkup on August 14, 1942, exhibiting general clinical improvement with weight gain and regression in breast size (Fig 3). The icteric index was 7. This improved state continued until January 1, 1943, when she returned with ascites, weight loss, paraplegia, and roentgen evidence of pulmonary metastasis. In July 1943 these symptoms had all progressed, and the patient expired on September 8, 19 months after having been clinically in a terminal state of her malignancy.

AUTOPSY EXAMINATION *Gross Findings*—The breasts appeared bilaterally atrophic, nodular, and fibrotic. Examination of the thoracic contents failed to reveal any evidence



FIG 3—Case I. Note spontaneous regression in size of both breasts (8-months follow-up).

of tumor metastasis. Each pleural cavity contained approximately 300 cc of clear straw-colored fluid. The peritoneal cavity contained 1000 cc of bloody fluid and revealed innumerable small tumor implants. The liver weighed 1,120 Gm and was almost completely replaced by tumor metastases. Several lumbar vertebrae were replaced by grayish-white tumor tissue. The ovaries together weighed 30 Gm and were diffusely involved. Metastatic adenopathy was not present in either the axillary or supraclavicular areas.

Microscopic Study—The tumor from the breast was composed of masses of tumor cells with some attempt at adenoid arrangement. Individual cells varied considerably in size and shape. They were uniformly quite irregular, with prominent nucleoli and pale pink cytoplasm. Infiltration was present in the surrounding breast and fat, and in areas of tumor growth the normal breast parenchyma was obliterated. Variable amounts of connective tissue stroma were present around the tumor and many small nests of tumor cells were present in lymphatics. It suggested acinar epithelial origin. The liver substance was diffusely replaced by tumor tissue which was also present in the wall of the gallbladder and in lymph nodes around the porta hepatis. The spleen and both lungs showed metastatic foci. Bone marrow of the ribs and vertebrae was extensively implicated by tumor. Both ovaries showed complete loss of ovarian substance by replacement with tumor tissue.

COMMENT

It was felt that this case presented two phases of possible ovarian influence on the breast malignancy first, the sequence of the original bilateral painful swelling of the breasts for four to five weeks, following the administration of estrogen substance. The second course of therapy was followed by an atypical bilateral diffuse malignancy originating from acinar epithelium of the breasts and associated with a generalized metastasis. These changes all occurred within the six-months period of the therapy which had started with clinically negative breasts. Secondly, the regression of the hopeless picture of generalized metastases, biliary obstruction, and hepatic damage observed in February 1942, followed by progressive improvement for 10 months, was thought to be explained by the loss of ovarian substance which occurred with the peritoneal spread.

The theory of an endocrine factor in premenopausal breast malignancy has its maximal support in the cases associated with the administration of hormonal therapy. However, the occurrence of such a combination is too infrequent to offer significance except perhaps as it applies to the individual case. Any hormonal influence which would be present in the majority of such cases would necessarily be as an endogenous factor.

On this basis, a study was made of all breast malignancies in patients under 50 years of age who were admitted to The Ellis Fischel State Cancer Hospital prior to 1946. Since this represented only a clinical study, specific endocrine factors could not be evaluated accurately, the evaluation was made on the endocrine balance as a whole picture. This series includes 39 cases, 30 of these presented fairly definite clinical evidence of deviation from a normal hormonal balance.

TABLE I

39 Cases were studied

GROUP A—25 were still in their normal menstrual life at the time of diagnosis of their tumor. Of these

- 1 16 (average age 46) gave menstrual histories of marked irregularity, including menorrhagia, oligomenorrhea, etc., dating from 5 to 28 years.
- 2 9 Gave normal menstrual histories without difficulties. However, the age of this group still in active menstrual life averaged 49.8 years.⁷

GROUP B—5 associated their growth's appearance with the onset of menstrual abnormalities, menorrhagia, and/or metrorrhagia of a duration of 2 to 16 months.

GROUP C—9 had undergone surgical termination of menses prior to the onset of their tumor.

While a fairly definite abnormal endocrine pattern was suggested in groups A-1 and B, Group C, forming 24 per cent of the total premenopausal cases, was the most suggestive of such an influence.

TABLE II

Patient	Operative Age	Operative Procedure	Age of Appearance of Breast Carcinoma	Follow-up
1	47	Complete hysterectomy + (?) for dysmenorrhea, menometrorrhagia	51	Inoperable
2	39	Complete hysterectomy and oophorec- tomy for cervical carcinoma	48	Recurrence and death
3	26	Left ovary removed for cyst	46	Inoperable
4	40	Right ovary removed for menorrhagia		
	35	Operated for fibroids (?)	50 (left breast)	1 yr post operative without re- currence
5	24	Menopausal symptoms followed Operation (?) Menorrhagia	51 (right breast)	Recurrence and death
6	31	Cessation of menstruation Left ovary and uterus—cause ?	51	Inoperable
7	42	Menometrorrhagia Operation done (?)	51	2 yrs post operative with recurrence
8	31	Pelvic operation Cause (?)	51	Inoperable
		Operation (?) Cessation of menstruation		
9	36	Dysmenorrhea and irregularities	38	1 yr post operative without recur- rence Opposite breast presenting marked nodularity

The variety of operative procedures which these patients received would preclude any correlation of a resulting effect. The presenting dysfunctions listed as necessitating surgical intervention all parallel the idea of a pre-existing severe endocrine imbalance. It would not be expected that such a hormonal pattern would be corrected by a surgical menopause.

CONCLUSION

The specific factors in the pattern of a malignant process remain unknown. It has been suggested by the cases presented that breast susceptibility to such a cellular change may be a variable, modified by the endocrine pattern. Clinically and pathologically our premenopausal group exhibited a virulent neoplasia, frequently including acinar epithelial elements, and associated with an endocrine pattern varying from physiologic normalcy. A prominent group of our cases presented a history of endogenous endocrine dysfunction, requiring previous surgical menopause. While the effect of estrogen administration cannot be evaluated accurately in its relation to premenopausal breast malignancy, it appears significant in the case presented.

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BOOK REVIEW

"The Aseptic Treatment of Wounds"

By CARL W. WALTER, M.D., THE MACMILLAN COMPANY,
NEW YORK

The publication of this important work marks an epoch in the history of surgery which competes in importance with many of the events in the evolution of asepsis outlined by the author in his opening chapters. Bringing to his subject the combined knowledge of the surgeon and the engineer, Dr. Walter has assembled in this volume the results of a decade of research and systematic compilation of data on the technology of asepsis. The title was selected for historical reasons as a tribute to Curt Schimmelbusch, who published in 1893 the first monograph on aseptic technic entitled "The Aseptic Treatment of Wounds," from which the first chapter of the new book is a verbatim quotation. However, in choosing this title the author has failed to convey a true indication of the breadth and encyclopedic detail of its content.

Starting with a comprehensive historical review of antiseptic and aseptic surgery, the author then discusses from scientific, technologic, and practical viewpoints the destruction of bacteria by chemical and physical agents. The thermal and bacteriologic characteristics of heat sterilization are presented in great detail, much of the data being derived from the author's own authoritative research in this field, and specific technics are described for sterilization of each item of equipment employed in the operating theater. The usefulness and limitations of chemical disinfectants in sterilization of instruments and skin are thoroughly considered. Full bibliographic references are supplied for each topic and constitute one of the most valuable features of the book. All of the procedures connected with provision of a sterile operative field, including the design and packaging of kits, the treatment of skin of patients and personnel, the control of air borne infection, the draping of the patient, and the wearing apparel of the surgical team, are taken up in clear and orderly fashion and illustrated by a profusion of excellent line drawings.

The concern which the author displays for preservation of the life of materials and instruments will be welcomed by the hospital administrator. The surgical chief and the operating room supervisor will find this book a standard reference by which to judge, in their own hospitals, the adequacy and efficiency of technics which may be rooted in fad and fancy rather than in the solid scientific data which support Dr. Walter's recommendations. He again goes beyond the limits of his title in his chapters on "Preparation of Parenteral Fluids" and "Blood and Plasma Facilities," but the hospital staff committee harrassed by an outbreak of infusion and transfusion reaction will be grateful to find the probable answer to their problem in this section. The hospital plumber or sanitation engineer will also have occasion to refer to this volume in connection with the maintenance and operation of sterilizing facilities and plumbing equipment. It may be hoped that the publication of this book will prompt the personnel of each and every hospital to re-examine its equipment.

and its manual of procedures, and *its practical use thereof*. Careful observance by the hospital staff of the principles and practices outlined in this monograph will leave to the individual surgeon the inescapable and undivided responsibility for the quality of healing of his clean operative wounds.

However efficient the modern complex hospital organization may be, it does not possess the "aseptic conscience", that is a personal quality of the individual surgeon and nurse and must be inculcated into every potential member of an operating team through intelligent teaching and precept. Here is a superb text for this purpose.

JOHN S. LOCKWOOD, M.D.

LETTERS TO THE EDITOR

DEAR SIR

The article entitled "Patho-physiology of the Cause of Death from Coronary Thrombosis," by Gordon Murray, which appeared in the October, 1947, issue of the ANNALS OF SURGERY, requires comment, especially in view of the broad clinical implications drawn by the author.

1 It should be noted that a description of the mechanical changes occurring in the zone of experimentally produced myocardial infarction was published by Tennant and Wiggers in 1935 ("The Effect of Coronary Occlusion on Myocardial Contraction"—Am J Physiol, 112: 351, 1935). The "Paradoxical Systole" observed by Murray was recorded and analyzed in great detail by Tennant and Wiggers with the aid of an optical recording Myograph. Simultaneous pressure pulses from the aorta or left ventricle were also recorded optically. The observations made by Murray confirm, but do not extend those previously made by Tennant and Wiggers. No acknowledgment of this prior work is made by Murray.

2 Although it is undoubtedly true that cardiac output will diminish in these experiments as a result of a fall in blood pressure (assuming a constant peripheral resistance), the method used by Murray for measuring left ventricular output is crude and hardly reliable.

3 It is incorrect to assume that the loss of contractility in the zone of myocardial infarction results in a state in any way similar to that which occurs following the development of a peripheral arteriovenous aneurysm. The primary hemodynamic alterations in A-V aneurysms are the result of the A-V shunt. This does not exist in myocardial infarction. It has been demonstrated that A-V aneurysms produce increased cardiac output, elevation of systolic and depression of diastolic pressure, and increased blood volume. Acute myocardial infarction results in very different, almost opposite changes.

4 The implication that practically all animals who are subjected to experimental coronary ligation die is not in accord with the fact, since it is well known that the survival rate of such preparations is about 50-75%. Control experiments are not described and referred to only obliquely.

5 The implication that infarction of the interventricular septum has a better prognosis than infarction elsewhere in the myocardium is not in accord with facts.

6 The mortality from acute myocardial infarction in human beings is 20-25% in the first 6 weeks following the clinical episode. The use of anti-

coagulant drugs may reduce this to 15-20% Hence, the prognosis following myocardial infarction is not as poor as implied by the statement " Medical treatment is so ineffective and is entirely helpless " The surgical risk involved in excising a segment of myocardium from a patient with a recent myocardial infarction cannot be dismissed as glibly as does Murray and would probably far exceed the 15-20% mentioned above Furthermore, it will be rather difficult for cardiologists to accept the undocumented statement, "The question of the anesthetic is not a serious one, because there is some evidence to suggest that a patient under ether anesthesia is in less danger with a coronary occlusion, than he is without the anesthetic "

7 Although Murray obtained an 80% survival rate following excision of the infarcted myocardium, similar experiments done by Drs E Sinaiko, B Kondo and myself on a small series of dogs in the Cardiovascular Department of Michael Reese Hospital (unpublished), resulted in a mortality rate of 100%

I believe that one should approach the clinical application of excision of an area of myocardial infarction with considerably more reserve than exercised by Murray

Sincerely, (signed) M R MALINOW, M D
Chief of Clinical Investigations
"Pabellon Inchauspe de Cardiologia"
Hospital Ramos Mejia
Buenos Aires, Argentina

✂ ✂ ✂

DEAR SIR

Thank you for your letter regarding a communication from Dr Malinow of Buenos Aires I was glad to receive the reference in the American Journal of Physiology I have looked this up and have noted —That Tennant and Wiggers in their article described a very nice instrument which has been placed on the area of infarction and which demonstrated first of all the contraction and subsequently the expansion of the infarcted area during systole They made no observations regarding the relationship of the area involved to the actively contracting muscle of the ventricle elsewhere They made no observations on the blood pressures or on the cardiac output before and after the occurrence of infarction of a portion of heart muscle They did not prove, as we have done, by excision of the infarcted area, that the effect produced in the general circulation of the animal and as well the cause of death, are the result of this expansion chamber, or as labelled "paradoxical systole" in the ventricle

In my article the premises for the investigation was, as stated, 1) To explain why patients run a low blood pressure following infarction of the heart and, 2) Why the patients die I think careful perusal of the article will show that the cardiac output is cut down to such an extent and the blood pressure falls to such an extent on this account that the animals are unable to survive, and the proof of this is that when the infarcted area is excised and the experiments are satisfactorily completed, the reverse is true

Sincerely yours, GORDON MURRAY

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